

Chapter 1

Introduction

Rhotics are known for the considerable phonetic variety they exhibit across languages and dialects. While most of the world's languages contain at least one rhotic phoneme, some languages have more than one, usually contrastive in type rather than place (Ladefoged and Maddieson 1996:237). A number of languages oppose two rhotic phonemes exclusively on the basis of duration: an extra-short coronal tap versus 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 patterns of neutralization. It is precisely this area of the phonology of rhotics—duration-based contrast and neutralization—that forms the topic of this dissertation.

Since SPE (Chomsky and Halle 1968), the generative literature has devoted much attention to rhotics in Iberian Romance, and Spanish in particular. The common property of all Spanish varieties is that two rhotics are in contrast only in intervocalic position within the word, while contrast is neutralized in all other positions. The trill occurs word-initially and after alveolar consonants. The tap occurs in other positions, but may be realized postlexically as a trill in emphatic or careful speech. Contemporary accounts of the intervocalic contrast have analyzed the trill either as a separate phoneme or as the geminate counterpart of the singleton tap. Syllable structure and sonority principles have also played important roles in accounting of the allophonic distribution of rhotics in positions of neutralization. Most recently, however, Bonet and Mascaró (1997)

acknowledge that by limiting their analytical 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). The main empirical goal of this dissertation is to demonstrate how Iberian Romance fits in among a broader typology of rhotic patterns.

1.1 A Typology of Rhotic Duration Contrast and Neutralization

On the basis of facts emerging from a comprehensive survey of languages with contrastive tap and trill, it will be argued that general Spanish pattern is merely one of three major phonotactic possibilities with respect to positions of contrast preservation.

Table 1–1 illustrates positions of word-level contrast and neutralization in the languages of the typological survey carried out in Chapter 3.¹

¹ Several language varieties with two contrastive rhotics must be excluded from the typology of *Table 1–1* because duration is not the relevant dimension of contrast. For instance, most varieties of European and Brazilian Portuguese contrast an alveolar tap and an uvular rhotic, with various phonetic manifestations in the latter, e.g., a voiced trill [R], a voiced fricative [ʀ], and a voiceless fricative [χ]. Similarly, the alveolar trill of general Spanish is realized with distinct manner and place specifications in some dialects, e.g., the prepalatal sibilant of Andean Spanish and other varieties, and the voiceless velar fricative of Caribbean varieties (see Lipski 1994). Beyond the Iberian Romance family, at least two languages have been reported to have a tap/trill contrast between vowels and word-initially: Guajiro (Mansen 1967) and Malayalam (Kumari 1973). Subsequent research suggests, however, that in both languages, the relevant contrast is one not of duration but of manner and/or place. Guajiro contrasts a lateral flap with an alveolar trill (Alvarez 1986). In Malayalam, one rhotic is a palatalized dental, while the other is an uvularized alveolar (McAlpin 1998). Like the Portuguese and Spanish varieties, Guajiro

is obligatory. In Chapter 4, I argue that this is only an apparent exception and demonstrate how neutralization to trill in word-initial position makes the Kurdish system *harmonically incomplete* in the sense of Prince and Smolensky (1993:185).

Table 1–1 also documents several generalizations regarding neutralization, which are summarized in (1.2):

- (1.2)
- a. Neutralization affects other positions within the word before it affects intervocalic position. Contrast is maintained between vowels in all of the languages surveyed.
 - b. In most of the languages surveyed, word-initial position either maintains contrast or exhibits neutralization to trill.
 - c. Word-initial tap entails taps also in heterorganic clusters and word-finally, as shown in Sebei. In contrast, word-initial trill does not entail obligatory trills in heterorganic clusters nor word-finally. This is demonstrated by Iberian Romance and Kurdish, in which the trill surfaces word-initially, while both the tap and trill surface in heterorganic clusters and word-finally—non-contrastively in Iberian Romance versus contrastively Kurdish.
 - d. Neutralization treats word-final position and heterorganic clusters as a natural class. No language neutralizes contrast in heterorganic clusters without also neutralizing it in word-final position, and vice-versa.
 - e. Rhotics do not cluster with homorganic consonants in six of the languages surveyed. In the remaining languages, the trill is obligatory under several types of coronal-adjacent configurations. Contrast is never allowed in homorganic clusters in any of the languages surveyed.

Since existing accounts have not considered languages beyond the Iberian Romance family, a comprehensive explanation for the above generalizations has yet to be developed. In Chapter 2, I present data from other languages of the typology that raise problems for previous syllable-based accounts of Spanish rhotics. I show that not all

aspects of the behavior of rhotics can be adequately captured with reference to syllable structure alone.

1.2 Theoretical Background and Assumptions

The theoretical goal of this dissertation is to develop a comprehensive analysis of the attested cross-linguistic patterns of rhotic duration contrast and neutralization shown in *Table 1–1*. The analysis is couched within the constraint-based framework of Optimality Theory (OT; Prince and Smolensky 1993, McCarthy and Prince 1993a,b, 1995).

Specifically, I argue that the observed typological patterns reflect distinct grammars, each predicted by different possible rankings of constraints on rhotic duration contrast and neutralization. Drawing upon the recent work of Flemming (1995), Kirchner (1997, 1998), and Steriade (1995a, 1997, 1999a, 2001a,b), I assume a version of OT in which phonetic and phonological constraints interact directly to determine the surface distribution of features without reference to syllable boundaries. Since reference to syllable structure is unnecessary, the analysis developed here does not face the same difficulties as existing syllable-based accounts when data beyond general Spanish are taken into account.

With respect to the phonotactics of the tap and trill, important aspects of the present analysis are the following:

- (1.3) Relevance of theoretical proposals to the analysis of rhotic duration contrast and neutralization
- a. Optimality Theory (Prince and Smolensky 1993; McCarthy and Prince 1993a,b, 1995)
Rhotic patterns are expressed in terms of ranked and violable constraints that apply in parallel.
 - b. Dispersion Theory (Flemming 1995)
Rhotic duration contrast is enforced directly in the surface representation without the need for underlying representation.
 - c. Segmental Autonomy (Steriade 1999a, 2001a)
Phonotactic restrictions on the distribution of rhotics are formulated in strictly linear terms without reference to syllable boundaries.
 - d. Licensing by Cue (Steriade 1995a, 1997, 1999a, 2001a,b)
The likelihood of rhotic duration contrast in a given context is a function of the relative perceptibility of the contrast in that context.

The following sections introduce relevant theoretical background by discussing each of the proposals in (1.3), beginning with the Optimality Theory framework. Section 1.3 then gives a preview of the analysis to be developed in subsequent chapters. Finally, Section 1.4 presents an overview of the dissertation.

1.2.1 Optimality Theory

Standard OT (Prince and Smolensky 1993; McCarthy and Prince 1993a,b) provides a framework for analysis in which ranked and violable constraints apply in parallel to determine the optimal mapping between input and output forms. This approach contrasts with derivational models in which ordered rules apply to yield a series of intermediate representations between input and output. In OT, two functions determine the optimal input-output mapping: GEN, which generates output candidates, and H-EVAL, which

selects the output candidate which best satisfies the constraints. The structure of an OT grammar is shown in (1.4):

(1.4) Structure of an OT grammar (Prince and Smolensky 1993:4)

- | | | | |
|----|--|---|---|
| a. | GEN (Input _k) | → | {Output ₁ , Output ₂ ...} |
| b. | H-EVAL (Output _i , 1 ≤ i ≤ ∞) | → | Output _{real} |

According to the Richness of the Base (ROTB) hypothesis (Prince and Smolensky 1993; see also Itô, Mester, and Padgett 1993, 1995; Kirchner 1995, 1997; Smolensky 1996, *inter alia*), there are no restrictions placed on input representations. Rather, output forms must be determined by the particular constraint ranking of the language in question. As Smolensky (1996) argues,

"[t]he source of all systematic cross-linguistic variation is constraint reranking. In particular, the set of inputs to the grammars of all languages is the same. The grammatical inventories of a language are the outputs which emerge from the grammar when it is fed the universal set of all possible inputs" (3).

The implication of the ROTB hypothesis is that all possible inputs must be dealt with in a given analysis. It is insufficient to stipulate that a certain segment or feature value does or does not belong in the phonological inventory of some language. Rather, the phonological behavior of segments and features must be shown to follow from the constraint system of that language.

Output candidates are evaluated in terms of their violations of the ranked constraints. Evaluations are shown in the form of a tableau:

(1.5) Input-output mappings are evaluated against constraints in an OT tableau

Input _k	CONSTRAINT A	CONSTRAINT B	CONSTRAINT C
Output ₁	*!		
☞ Output ₂			*
Output ₃			**!

The input appears in the first cell of the tableau, while output candidates are shown below in the same column. Constraints are given along the top of the remaining columns. A crucial ranking between two constraints is indicated by a solid line separating the two columns. For example, tableau (1.5) represents a language in which three hypothetical constraints are ranked as follows: CONSTRAINT A » CONSTRAINT B, CONSTRAINT C. That is, CONSTRAINT A outranks CONSTRAINT B, but CONSTRAINT B is unranked with respect to CONSTRAINT C. A constraint violation is indicated by an asterisk. If a violation causes an output candidate to be eliminated from the evaluation, then that violation is said to be fatal, and the symbol '!' appears next to the relevant asterisk. The symbol '☞' marks the winning output candidate (i.e., the candidate that remains after all others are eliminated). Cells are shaded to indicate that any violations which they may contain are irrelevant to the evaluation.

As an illustration, let us consider the evaluation shown in tableau (1.5). Output₁ violates CONSTRAINT A, which is top-ranked. Since there are other candidates that do not violate this constraint, Output₁ is eliminated from consideration, and the lower-ranked constraints are now irrelevant to this candidate, as indicated by the shaded cells. None of the remaining candidates violates CONSTRAINT B. With respect to CONSTRAINT C, however, Output₂ incurs a single violation, while Output₃ incurs two violations. A

candidate that multiply violates some constraint loses to any candidate that violates the same constraint to a lesser degree. The second violation of CONSTRAINT C by Output₃ is a fatal one, and Output₂ is selected as the winner.

To summarize, OT provides a framework in which phonological systems are expressed in terms the ranked and violable constraints. Grammars consist of "a set of highly general constraints which, through ranking, interact to produce the elaborate particularity of individual languages" (Prince and Smolensky 1993:198). See Prince and Smolensky (1993) for a more detailed presentation of this formalism.

1.2.2 Evolving Conceptions of Phonological Contrastiveness

This section examines how views of phonological contrastiveness have shifted over the years from an abstract, representational model to one in which contrast is seen as an epiphenomenon of constraint ranking. The goal here is to motivate the second theoretical assumption of this dissertation: phonological contrast is enforced directly in the surface representation without the need for underlying representation.

Phonologically contrastive features have traditionally been assumed to constitute a subset of the total number of phonetic features that characterize speech sounds.

Attempts to determine the proper set of phonological features have typically lead to the exclusion of those phonetic properties that never serve as the sole basis of contrast. This reductionist trend is expressed by Jakobson and Halle (1962:483), who argue that "[t]he supposed multiplicity of features proves to be largely illusory." Keating (1984) takes a similar view by criticizing proposals of Halle and Stevens (1973):

"Halle and Stevens (and SPE) don't simply have the wrong features in these instances; *they will always have too many features* because they want to describe exactly how individual sounds are articulated. While we want phonological features to have some phonetic basis, we also want to distinguish possible contrasts from possible differences" (289).

These assumptions reflect the representational view of phonological contrast. Underlying representation encodes contrast in an abstract manner, and non-contrastive features are generally not specified as part of the representation. Subsequently, phonological operations derive a surface representation, which is ultimately provided with rich phonetic detail by an implementation component. This model is shown in *Figure 1-1*.

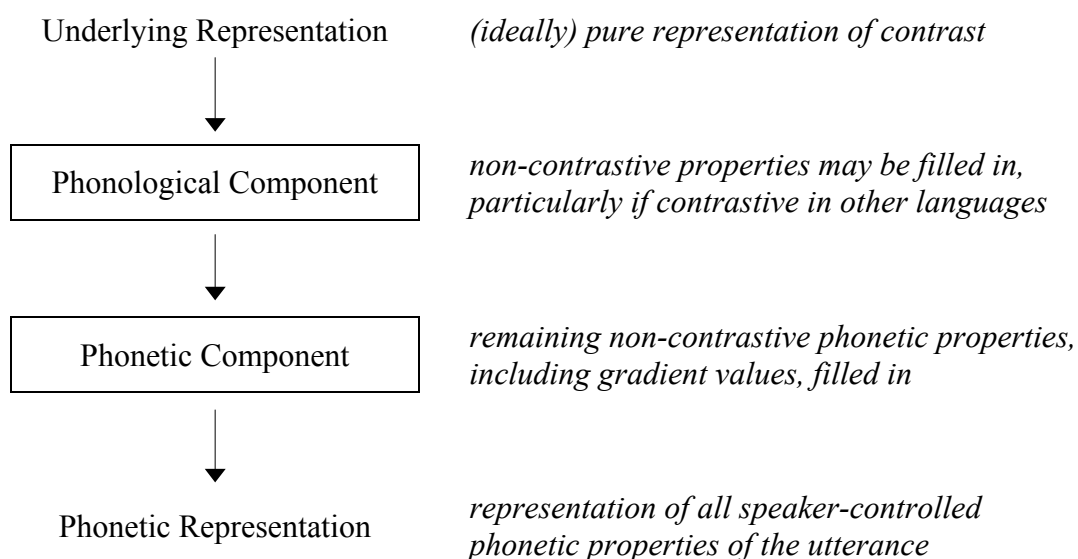


Figure 1-1: The standard (representational) treatment of contrastiveness (from Kirchner 1998:60)

Steriade (1995b) identifies several problems with this model. For example, the feature [sonorant] defines such an important natural class of segments that phonologists have typically assumed it to be present at the earliest derivational stages, despite the fact that its value is predictable in nasal segments, oral stops, and vowels. Similarly, syllable

structure is considered to play a fundamental role in the derivation, yet it is never contrastive per se in any language. According to the model of contrastiveness in *Figure 1-1*, the feature [sonorant] and syllable structure should be absent from deep derivational levels, since the former is predictable and the latter is never contrastive. Another criticism stems from the fact that some feature contrasts are licensed in certain positions but not others. While representational restrictions may be invoked to explain the lack of contrast, so may neutralization rules or constraints. The availability of both analytical approaches to positional neutralization constitutes a redundancy in the theory.³

Kirchner (1997, 1998) proposes to abandon the representational model by shifting the burden of contrast onto the constraint system. Specifically, contrastiveness is argued to be an epiphenomenon of the interaction between markedness and faithfulness constraints in the OT sense, without resorting to the representational and derivational assumptions of the standard model shown in *Figure 1-1*. As Kirchner argues, one of the benefits of assuming the ROTB hypothesis is that phonological representations are free to include non-contrastive aspects of phonetic detail, such as duration or consonantal release. Such a move allows phonetic explanations for phonological patterns to be captured directly. The following section shows how Correspondence Theory (McCarthy and Prince 1995) permits an account of phonological contrastiveness in terms of constraint ranking.

³ See Kirchner (1998:60-62) for further criticism of the representational model of contrastiveness.

1.2.2.1 Correspondence Theory

In Correspondence Theory (McCarthy and Prince 1995), constraints assess correspondence and identity of correspondent elements between phonological strings. For example, the constraint on featural correspondence in (1.6) strives to maintain identical specifications between two strings with respect to some feature F. The constraint in (1.7) is a specific instantiation of (1.6) that regulates input and output strings:

(1.6) IDENT(F)
 Let α be a segment in S_1 and β be any correspondent of α in S_2 .
 If α is $[\gamma F]$, then β is $[\gamma F]$.
 (Correspondent segments are identical in feature F).

(1.7) IDENT-IO(F)
 Output correspondents of an input $[\gamma F]$ segment are also $[\gamma F]$.

The faithfulness constraint IDENT-IO(F) ensures that underlying specifications for some feature F will surface faithfully in the output. Input-output correspondence thus has a fundamental role in OT, namely that of ensuring contrast.⁴ Specifically, a feature F is contrastive in a grammar if there is an input-output correspondence constraint on F that outranks markedness constraints on the surface distribution of some value of F. Two separate tableaux are required to fully demonstrate F contrast, one for each underlying F value:

⁴ Correspondence Theory has supplanted the earlier containment-based faithfulness constraints PARSE and FILL (McCarthy and Prince 1993a, Prince and Smolensky 1993).

(1.8) High-ranking IDENT–IO(F) ensures recovery of underlying F contrast

/+F/	IDENT–IO(F)	*[+F]
☞ [+F]		*
[–F]	*!	

/–F/	IDENT–IO(F)	*[+F]
[+F]	*!	*
☞ [–F]		

In each tableau above, high-ranking IDENT–IO(F) gives a fatal violation mark to the output candidate whose F value differs from the input value. Input-output correspondence thus ensures that output values for F are identical to the input values.

On the other hand, if markedness constraints against F values outrank IDENT–IO(F), then the feature F is not contrastive, regardless of input specifications. This is demonstrated by the tableaux in (1.9):

(1.9) Low-ranking IDENT–IO(F) ensures that F is not contrastive

/+F/	*[+F]	IDENT–IO(F)
[+F]	*!	
☞ [–F]		*

/–F/	*[+F]	IDENT–IO(F)
[+F]	*!	*
☞ [–F]		

Since markedness against [+F] always ensures [–F] in the output, input specifications of F are irrelevant. There can be no surface F contrast under this ranking because it is impossible for underlying /+F/ to surface faithfully.

In sum, the contrastiveness of a particular feature depends on the relative ranking of correspondence and markedness constraints relevant to that feature. On this view, it is no longer necessary to impose restrictions on underlying representation. *Figure 1–2* illustrates this model of phonological contrast:

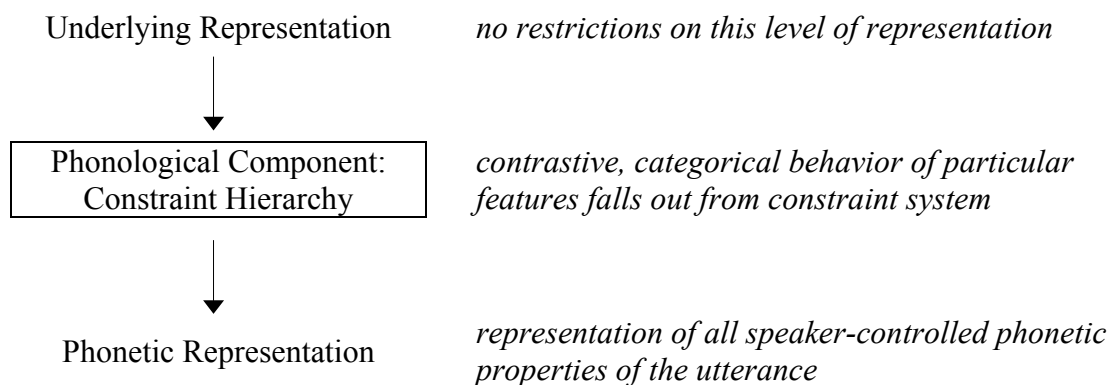


Figure 1–2: A constraint-ranking treatment of contrastiveness (from Kirchner 1998:63)

Since there are no restrictions on the input in this model, aspects of phonetic detail need not be excluded from underlying representations. The feature F appearing in the hypothetical tableaux (1.8) and (1.9) could plausibly refer to non-contrastive phonetic categories such as [extra-short closure] or [release], which would be excluded under the representational model of phonological contrast in *Figure 1–1*. Since contrastiveness of a given feature is determined independently by the constraint system, phonetic detail can play a direct role in the phonology without the threat of overgenerating spurious contrasts.

1.2.2.2 Dispersion Theory

Flemming (1995) proposes to eliminate input-output correspondence and underlying representations from the theory by appealing to constraints that demand contrast directly in the output. Working from the Theory of Adaptive Dispersion of Lindblom (1986, 1990) and others, Flemming develops constraint-based Dispersion Theory in order to

account for the language-specific selection of contrastive sound categories. According to the theory, inventory selection involves striking a balance among three goals:

(1.10) Three goals in the selection of contrasts

- a. Maximize the number of contrasts.
- b. Maximize the distinctiveness of contrasts.
- c. Minimize effort.

Goals (1.10a) and (1.10b) are inherently conflicting. Since contrasting categories share perceptual space along some auditory dimension, fitting more contrasts into that space implies that those contrasts cannot be as distinct as a smaller set. However, when there is only one contrast between two sound categories, goal (1.10b) is no longer at issue because there are no other contrasts from which the existing one must be kept perceptually distinct. This is the case of rhotic duration contrast, in which there is a single contrast between the coronal tap and trill. For present purposes, I conflate (1.10a) and (1.10b) into a single CONTRAST(F) constraint, which seeks to maintain a surface contrast in some feature F:

(1.11) CONTRAST(F)

Maintain a surface contrast in [α F] with sufficient perceptual distance.

This view of contrastiveness allows consideration of surface forms alone and requires no reference to underlying representation. Lexical entries correspond to surface representations, which are themselves determined by the constraint system. Since CONTRAST(F) does not refer to input forms, one tableau is sufficient to demonstrate contrastiveness (cf. (1.8), where two tableaux are required under input-output correspondence). The collapse of two tableaux into one is more than a simple expository

convenience. Rather, it follows from the fact that Dispersion Theory enforces phonological contrast directly among surface forms, while input-output correspondence requires reference to input forms.

Now, when CONTRAST(F) outranks markedness constraints on the surface distribution of F values, the result is maintenance of a surface F contrast.

(1.12) High-ranking CONTRAST(F) demands F contrast directly in the output⁵

	CONTRAST(F)	*[+F]
☞ [+F] ≠ [-F]		*
[+F]	*!	*
[-F]	*!	

The winning candidate in (1.12) maintains two distinct surface values for F, as indicated by the ≠ symbol that intervenes between the two contrastive output specifications for [F]. CONTRAST(F) rules out candidates in which contrast is neutralized to one particular F value. When markedness constraints outrank CONTRAST(F), no contrast is possible with respect to the feature F, as demonstrated by tableau (1.13):

(1.13) Low-ranking CONTRAST(F) ensures neutralization of F contrast

	*[+F]	CONTRAST(F)
[+F] ≠ [-F]	*!	
[+F]	*!	*
☞ [-F]		*

⁵ Markedness constraints such as the hypothetical *[+F] in tableau (1.12) embody the third goal in the selection of contrasts shown in (1.10c), namely that articulatory effort should be minimized.

Markedness against [+F] always ensures [-F] in the output under this ranking.

Neutralization of F contrast is guaranteed without reference to input specifications.

To sum up, Correspondence Theory permits an account of the contrastiveness of features without imposing restrictions on underlying representation. Dispersion Theory goes one step further by eliminating underlying representation altogether. In this dissertation, I adopt a surface-oriented approach to phonological contrast. I propose constraints on rhotic duration contrast which operate directly on surface representations without reference to underlying representation. Input forms are considered unnecessary and are omitted from the tableaux, as shown in (1.12) and (1.13). In Section 3.3.4.1.1 of Chapter 3, evidence is presented from restrictions on hypercorrective /s/-epenthesis in Dominican Spanish which supports surface-oriented Dispersion Theory over input-output correspondence.

1.2.3 Consonantal Phonotactics Without The Syllable

Blevins (1995:207) defines the syllable as a structural unit that organizes segmental melodies in terms of their inherent sonority. As a phonological constituent, the syllable plays a central role in contemporary phonological theory. This unit has served as an analytical tool in several empirical domains, including speaker intuitions of string division, stress assignment, and phonotactic knowledge of permissible segment sequences. In syllable-based analyses, it is often claimed that some generalization is more succinctly stated in terms of the syllable than without it. For instance, some languages appear to have phonological rules that apply at syllable edges. Without reference to the

syllable, such rules must be formulated so that they target two distinct contexts, namely adjacent to word boundary and adjacent to a consonant. This is demonstrated by the following schematic rules targeting consonants:

(1.14) Phonological rules that target consonants at syllable edges without reference to syllable position

- a. $\alpha \rightarrow \beta / _ \{ \#, C \}$
- b. $\alpha \rightarrow \beta / \{ \#, C \} _$

The problem is that boundary symbols and consonants do not form a natural class in the structural description of the rules. The generalization missed by (1.14a) and (1.14b) is that α is syllable-final in the former and syllable-initial in the latter. Reference to syllable structure permits a more precise statement of the environments in which these rules apply.

Despite the greater formal simplicity afforded by the syllable, recent research has uncovered some cases in which syllable-based phonotactic statements make the wrong predictions cross-linguistically. Steriade (1997, 1999a, 2001a) argues that this is true with respect to patterns of voicing neutralization, aspiration, and place assimilation. In the following sections, I examine obstruent voicing neutralization as a representative case, beginning with a critique of constraint-based approaches that make reference to syllable position. The reason for examining this aspect of laryngeal phonology is that it closely parallels the case of rhotic duration contrast and neutralization. As in the domain of obstruent voicing patterns, reference to syllable structure alone is insufficient to account for all aspects of the behavior of rhotics.

1.2.3.1 Syllable-based Neutralization

Phonotactic restrictions govern the occurrence and combinatorial possibilities of segments or feature specifications. Restrictions on feature specifications naturally affect the distribution of contrasts involving those features. One example from the literature on laryngeal neutralization is syllable-final obstruent devoicing. In languages that have this restriction, obstruents are distinctively voiced only when followed by a vowel or sonorant. Given that prevocalic obstruents are typically syllable onsets and that obstruent-sonorant sequences are possible onset clusters, it is tempting to formalize a phonotactic statement about distinctive obstruent voicing in syllable-based terms, as in (1.15).

- (1.15) Syllable-based phonotactic statements of distinctive obstruent voicing
- a. A voiced obstruent is an onset. (Goldsmith 1990)
 - b. A voiced obstruent is followed by a tautosyllabic sonorant. (Lombardi 1995)

As Steriade (1999a) points out, constraint-based formulations of the statements in (1.15a,b) come in two flavors. In the *syllabic markedness* approach, context-free correspondence constraints are ranked against markedness constraints that target particular syllable positions. In the *syllabic faithfulness* approach, correspondence constraints are syllable-sensitive, while markedness constraints are context-free. These two approaches are exemplified by the constraint rankings in (1.16). (N.B.: Here, I adopt the surface-oriented CONTRAST(F) constraints of Dispersion Theory instead of the IDENT-IO constraints of Correspondence Theory.)

(1.16) Syllable-based approaches to phonotactic restrictions on obstruent voicing

- a. Syllabic markedness ranking
*[+voi]/coda » CONTRAST(voi) » *[+voi]
- b. Syllabic faithfulness ranking
CONTRAST(voi/onset) » *[+voi] » CONTRAST(voi)

Under the syllabic markedness ranking in (1.16a), distinctive obstruent voicing is generally maintained by the ranking of CONTRAST(voi) » *[+voi], except in coda position, where [+voi] is positionally marked by the highest-ranked *[+voi]/coda constraint. The tableaux in (1.17) illustrate the effects of coda devoicing on obstruent voicing contrast, with hypothetical output forms:

(1.17) Obstruents are devoiced in coda, distinctively voiced in onset

	*[+voi]/coda	CONTRAST(voi)	*[+voi]
a. Vd] ≠ Vt]	*!		*
b. Vd]	*!	*	*
☞ c. Vt]		*	

	*[+voi]/coda	CONTRAST(voi)	*[+voi]
☞ d. [dV ≠ [tV			*
e. [dV		*!	*
f. [tV		*!	

Candidate (1.17c) is optimal because it lacks a syllable-final voiced obstruent, as ensured by the high-ranking *[+voi]/coda. However, in the second tableau, the positional markedness constraint is no longer operative because the obstruent is in onset position. Therefore, the decision falls to CONTRAST(voi), which preserves distinctive voicing in the

optimal candidate (1.17d). Candidates (1.17e,f) are ruled out because [voice] is neutralized to one particular specification.

Under the syllabic faithfulness ranking in (1.16b), contrast is generally neutralized by the ranking of $*[+voi] \gg \text{CONTRAST}(voi)$, except in onset position, where distinctive obstruent voicing is ensured by $\text{CONTRAST}(voi/onset)$. The tableaux in (1.18) illustrate this, again with hypothetical output forms:

(1.18) Obstruents are devoiced in coda, distinctively voiced in onset

	CONTRAST(voi/onset)	*[+voi]	CONTRAST(voi)
a. Vd] ≠ Vt]		*!	
b. Vd]		*!	*
☞ c. Vt]			*

	CONTRAST(voi/onset)	*[+voi]	CONTRAST(voi)
☞ d. [dV ≠ [tV		*	
e. [dV	*!	*	*
f. [tV	*!		*

In the first tableau, the context-free markedness constraint $*[+voi]$ encodes a general ban against voiced obstruents. Neutralization to $[-voi]$ is optimal as shown by the winning candidate (1.18c). When the obstruent is in onset position, as in the second tableau, the positional constraint $\text{CONTRAST}(voi/onset)$ functions to preserve obstruent voicing contrast by optimizing candidate (1.18d).

Syllabic markedness and syllabic faithfulness approaches differ with respect to which type of constraint is relativized to syllabic position. Both approaches achieve the

same effect, namely that of ensuring obstruent voicing contrast in onset position while neutralizing the contrast in coda position.

1.2.3.2 The Segmental Autonomy Hypothesis

Steriade (1995a, 1999a) argues against syllable-based generalizations such as those in (1.15). According to the Segmental Autonomy hypothesis, reference to syllable position is unnecessary—and often insufficient—in the proper formulation of phonotactic restrictions. Rather, phonotactic statements are best understood as syllable-independent, string-based conditions reflecting positional differences in the perceptibility of contrasts. One alternative to the statements in (1.15) is to formulate the phonotactic restriction in strictly linear terms, as in (1.19):

(1.19) Syllable-independent phonotactic statement of distinctive obstruent voicing

A voiced obstruent is followed by a sonorant. (Steriade 1999a)

Evidence in support of the formulation in (1.19) comes from languages in which distinctive obstruent voicing is maintained before sonorants regardless of the location of syllable boundaries. The Lithuanian data in (1.20) show that coda obstruents contrast in voicing before sonorants but not before obstruents, despite the fact that the relevant clusters are heterosyllabic in each case:

(1.20) Obstruent voicing contrast and neutralization in Lithuanian heterosyllabic clusters (see Steriade 1997:17–18)

a. Contrast before sonorants

<i>sil</i> [p.n] <i>as</i>	'weak'	<i>sko</i> [b.n] <i>is</i>	'table'
<i>à</i> [t.m] <i>inti</i>	'to remember'	<i>liũ</i> [d.n] <i>as</i>	'sad'
<i>a</i> [k.m] <i>uõ</i>	'stone'	<i>au</i> [g.m] <i>uõ</i>	'growth'

b. Neutralization before obstruents

<i>dir</i> [p.t] <i>i</i>	'work–INF'
<i>a</i> [d.g] <i>al</i>	'back'
<i>dè</i> [k.t] <i>i</i>	'burn–INF'

Obstruent voicing is phonologically contrastive before sonorants in (1.20a). However, contrast is neutralized before other obstruents, as evidenced by the uniform voicing specifications shared by the clusters in (1.20b)

The inadequacy of syllable-based approaches to the data in (1.20) is demonstrated by the tableaux in (1.21), in which the idealized output forms [p.N] and [b.N] represent the Lithuanian examples *silpnas* 'weak' and *skobnis* 'table', respectively. (N.B.: The ☛ symbol indicates that the constraints have incorrectly optimized a particular candidate.)

(1.21) Syllabic markedness and faithfulness rankings incorrectly predict neutralization before sonorants in Lithuanian

	*[+voi]/coda	CONTRAST(voi)	*[+voi]
a. b.N ≠ p.N	*!		*
b. b.N	*!	*	*
☛ c. p.N		*	

	CONTRAST(voi/onset)	*[+voi]	CONTRAST(voi)
d. b.N ≠ p.N		*!	
e. b.N		*!	*
☛ f. p.N			*

The positional markedness constraint *[+voi]/coda incorrectly prohibits distinctively voiced /b/ from coda position and selects candidate (1.21c) as the winner. Similarly, the positional faithfulness constraint CONTRAST(voi/onset) is irrelevant in coda position, such that context-free *[+voi] incorrectly selects candidate (1.21f) as the winner. Both approaches fail to capture a significant generalization, namely that distinctive obstruent voicing is maintained before a following sonorant regardless of the obstruent's position within the syllable.

The existence of obstruent voicing patterns like that of Lithuanian suggests that phonotactic constraints should be formalized on the basis of linear statements like the one in (1.19). As with syllable-based accounts, one may formulate syllable-independent constraints in one of two ways, as shown in (1.22a) and (1.22b).

(1.22) Syllable-independent approaches to phonotactic restrictions on obstruent voicing

- a. Positional markedness ranking
 $*[+voi]/V_{[-son]} \gg \text{CONTRAST}(voi) \gg *[+voi]/V_{[+son]}$
- b. Positional faithfulness ranking
 $\text{CONTRAST}(voi/V_{[+son]}) \gg *[+voi] \gg \text{CONTRAST}(voi/V_{[-son]})$

Under the positional markedness ranking in (1.22a), distinctive obstruent voicing is maintained before sonorants by the ranking of context-free $\text{CONTRAST}(voi)$ above the markedness constraint against distinctive [voice] in presonorant position. In contrast, the positional faithfulness ranking in (1.22b) preserves distinctive voicing before sonorants because the context-specific $\text{CONTRAST}(voi/V_{[+son]})$ outranks context-free markedness.

The effects of these rankings are illustrated by the tableaux in (1.23):

(1.23) Positional markedness and faithfulness rankings correctly allow distinctive voicing in heterosyllabic obstruent + sonorant clusters

	$*[+voi]/V_{[-son]}$	$\text{CONTRAST}(voi)$	$*[+voi]/V_{[+son]}$
☞ a. b.N ≠ p.N			*
b. b.N		*!	*
c. p.N		*!	

	$\text{CONTRAST}(voi/V_{[+son]})$	$*[+voi]$	$\text{CONTRAST}(voi/V_{[-son]})$
☞ d. b.N ≠ p.N		*	
e. b.N	*!	*	
f. p.N	*!		

To summarize, Segmental Autonomy is the hypothesis that phonotactic constraints are independent of the location of syllable boundaries. Linear, string-based statements are necessary in order to give a full account of laryngeal neutralization

patterns in languages like Lithuanian. The relevance of the preceding discussion of laryngeal neutralization is that in some languages, positional restrictions on rhotics must also be formulated in syllable-independent terms. In Chapter 3, we will see that both contrast and markedness constraints must be relativized to certain positions in order to account for the complete typology of rhotic patterns. In order to simplify the discussion in the remainder of this chapter, however, I will simply assume the positional faithfulness approach.

1.2.4 Constraint Hierarchies and Licensing by Cue

The positional faithfulness constraints in (1.22b) belong to a universally ranked hierarchy of constraints, shown in (1.24), all of which are formulated in accordance with Segmental Autonomy:

(1.24) Positional faithfulness hierarchy for distinctive obstruent voicing

$$\begin{array}{c} \text{CONTRAST(voi/V_ [+son])} \\ | \\ \text{CONTRAST(voi/V_ \#)} \\ | \\ \text{CONTRAST(voi/V_ [-son])} \end{array}$$

In this section, I make two important points with respect to this universal ranking of constraints. First, the hierarchy is shown to make correct typological predictions with respect to positions of obstruent voicing contrast and neutralization. Second, the universal ranking derives from perceptibility considerations and is, therefore, motivated independently of the phonological patterns it seeks to predict.

By ranking the markedness constraint $*[+voi]$ at various positions along the positional faithfulness hierarchy in (1.24), different patterns of [voice] neutralization are predicted to occur. These patterns are shown in (1.25), along with the rankings that generate them:

(1.25) a. Contrast before sonorants only:

CONTRAST(voi/V_[+son])
 |
***[+voi]**
 |
 CONTRAST(voi/V_#)
 |
 CONTRAST(voi/V_-[-son])

b. Contrast before sonorants and word-finally:

CONTRAST(voi/V_[+son])
 |
 CONTRAST(voi/V_#)
 |
***[+voi]**
 |
 CONTRAST(voi/V_-[-son])

c. Contrast before sonorants, word-finally, and before obstruents:

CONTRAST(voi/V_[+son])
 |
 CONTRAST(voi/V_#)
 |
 CONTRAST(voi/V_-[-son])
 |
***[+voi]**

As Steriade (1997) documents, the patterns in (1.25) are cross-linguistically attested. The ranking in (1.25a) accounts for Lithuanian and several other Indo-European languages, including Greek, Sanskrit, Russian, Polish, and German. The ranking in (1.25b) is

appropriate for Hungarian and Kolami, while that in (1.25c) covers Maithili, Lamani, Shilha, and various Arabic dialects.

The rankings in (1.25) express an important typological generalization: there are no grammars in which voicing is neutralized word-finally but not before obstruents. Since the ranking of CONTRAST(voi/V_#) over CONTRAST(voi/V_[-son]) is universally fixed, the ranking of *[+voi] above the former entails, by transitivity of constraint ranking, that it will also be ranked above the latter. Therefore, it is impossible for voicing neutralization to affect obstruents in word-final position without also affecting those occurring before other obstruents. This implicational asymmetry is captured directly by the positional faithfulness hierarchy.

An important question arises regarding the universal rankings of positional constraints in (1.24). Is there some independent motivation for these rankings other than the cross-linguistically attested patterns of laryngeal neutralization? In the absence of such motivation, the analysis is subject to the same accusations of circularity that are often leveled against the sonority hierarchy. Gerfen (2001) makes the following observation regarding sonority:

"Undeniably, there is a fundamental circularity in using observed patterns of segmental ordering in syllables to derive a sonority hierarchy and subsequently using the same hierarchy to *explain* the possible orderings of segments within syllables. This is not to say that such a hierarchy fails to make predictions about the likelihood of finding particular syllable types in natural language, but it offers little in the way of understanding why such patterns arise" (200).

In order to avoid circularity in the analysis, it is preferable to derive patterns of laryngeal neutralization from the physiological and physical properties of speech production and perception (cf. Ohala 1990, Lindblom 1990). As it turns out, the hierarchy in (1.24) is

motivated independently of the neutralization patterns it seeks to derive. Specifically, the constraint rankings are grounded in facts of contrast perceptibility.

In the Licensing by Cue framework of Steriade (1995a, 1997, 1999a, 2001a), speakers are assumed to possess knowledge of the physical conditions under which contrasts are implemented. Contrast is neutralized in positions where the relevant auditory cues are diminished, while contrast is licensed in positions where cues are perceptually salient. As Steriade (1999a) argues, "the likelihood that distinctive values of the feature F will occur in a given context is a function of the relative perceptibility of the F-contrast in that context" (4). To understand why the positional hierarchy in (1.24) is the way it is, we must examine the nature of cues to distinctive obstruent voicing in various contexts. *Table 1–2* displays three segmental contexts and the cues to contrast that are potentially available there:

Table 1–2: Cues to obstruent voicing in different segmental contexts (based on Steriade 1997:6–7)

	V_[+son]	V_#	V_[-son]
VOT value	✓		
F ₀ and F ₁ values at the onset of voicing in V ₂	✓		
burst duration and amplitude	✓	✓	
V ₁ duration	✓	✓	✓
F ₀ and F ₁ values in V ₁	✓	✓	✓
closure voicing	✓	✓	✓
closure duration	✓	✓	✓

The greater the number of obstruent voicing cues there are in a given context, the more perceptible the contrast is in that context.

The perceptibility scale in (1.26) encapsulates the observation that obstruent voicing contrast is most perceptible before sonorants, less perceptible in word-final position, and least perceptible before obstruents. (N.B.: The ▷ symbol means that voicing in a given context is more perceptible than in the context listed to its right.)

(1.26) Perceptibility scale for distinctive obstruent voicing

$$V_{+son} \triangleright V_{\#} \triangleright V_{-son}$$

The speaker's knowledge of the physical conditions governing obstruent [voice] contrast can be modeled in OT using Prince and Smolensky's (1993:135) notion of harmonic alignment, whereby constraint hierarchies are aligned to harmonic scales. Specifically,

positional CONTRAST(voi) constraints are ranked in parallel with the contexts of the perceptibility scale, as demonstrated in *Figure 1–3*:

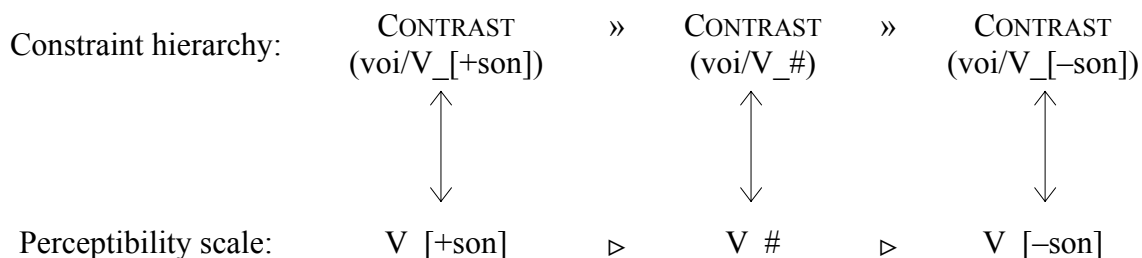


Figure 1–3: Alignment of positional CONTRAST(voi) constraints to the perceptibility scale for distinctive obstruent voicing

The highest-ranked CONTRAST(voi/V_[+son]) constraint is aligned to the highest position on the scale, V_[+son]. The procedure continues rightward until all CONTRAST(voi) constraints have been aligned to their corresponding positions on the perceptibility scale. Crucially, the universal ranking of constraints in this hierarchy is determined by perceptibility conditions. Contexts of greater perceptibility are more likely to maintain distinctive values for obstruent voicing, while contexts of diminished perceptibility are more likely to be targeted by neutralization.

1.2.5 Summary

To summarize the discussion of theoretical assumptions, Correspondence Theory has been shown to permit an account of phonological contrastiveness without imposing representational restrictions on underlying forms, as illustrated in *Figure 1–2*. Dispersion Theory carries the assault against underlying representation to its logical conclusion by

obviating the need for this level altogether. With respect to consonantal phonotactics, syllable-based statements do not always make the right cross-linguistic predictions. This was shown to be true with respect to obstruent voicing neutralization, which lends support to the Segmental Autonomy hypothesis that consonantal phonotactics reflect linear, string-based conditions. Finally, Licensing by Cue makes explicit the link between phonological contrastiveness and perceptibility, thereby providing an empirically superior alternative to syllable-based phonotactic accounts. The resulting organizational view of phonology—and the view assumed in this dissertation—is shown in *Figure 1–4*.

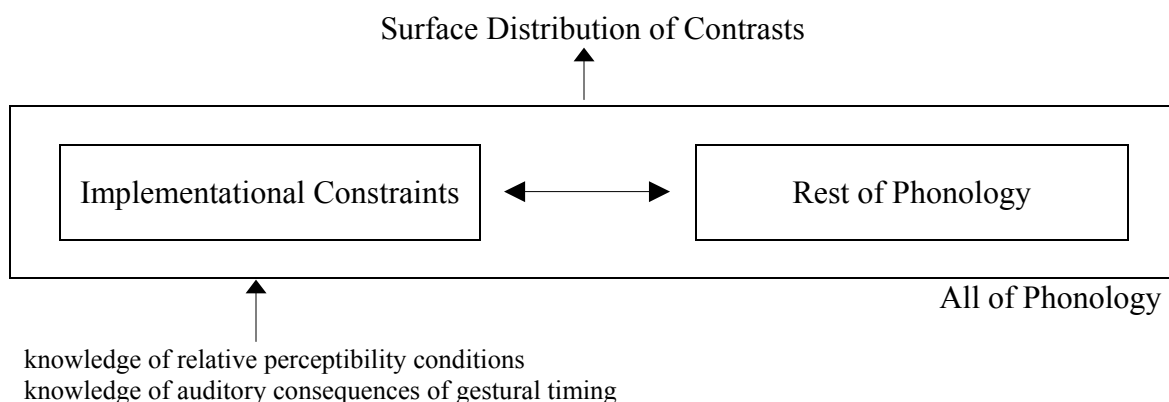


Figure 1–4: A phonetically-based OT model in which phonetic and phonological constraints interact directly without underlying representation (from Steriade 1997:3)

1.3 Analysis of The Rhotic Duration Typology: A Preview

In Chapter 3 of this dissertation, I develop a phonetically-based OT analysis of rhotic duration contrast and neutralization. This section previews the major constraints of the

analysis and demonstrates how typological patterns emerge as a consequence of their interaction under different rankings.

1.3.1 Contrast Maintenance Constraints

In Section 3.1 of Chapter 3, the perceptual and articulatory properties of the tap and trill are examined, and the following perceptibility scale for distinctive rhotic duration is proposed:

$$(1.27) \quad V_V \triangleright \#_V \triangleright C_V, V_C, V_ \#$$

Alignment of the CONTRAST constraints in (1.28a–c) to this scale results in the universal ranking shown in (1.28d):

- (1.28) Constraints governing the maintenance of rhotic duration contrast
- a. CONTRAST(duration/V_V)
Maintain rhotic duration contrast between vowels
 - b. CONTRAST(duration/#_V)
Maintain rhotic duration contrast word-initially
 - c. CONTRAST(duration)
Maintain rhotic duration contrast
 - d. Universal ranking
CONTRAST(dur/V_V) » CONTRAST(dur/#_V) » CONTRAST(dur)

The ranking of these constraints is motivated by positional differences in the perceptibility of distinctive rhotic duration. The contrast between the tap and trill is most perceptually salient in intervocalic position. Similarly, the perceptual prominence of word

onsets places word-initial position above all other non-intervocalic positions within the word.

Since there are separate, higher ranking constraints targeting intervocalic and word-initial positions, the remaining positions within the word are targeted by a single context-free constraint, CONTRAST(duration). An interesting prediction of this ranking is that heterorganic clusters and word-final position form the natural class of "elsewhere" contexts. This prediction is typologically accurate, as demonstrated by the implicational relationships observed among contrastive positions shown in (1.1), which I repeat here for convenience:

(1.29) Position 1 < Position 2 < Position 3
 Intervocalic Word-initial Heterorganic clusters,
 Word-final

where contrast in Position x entails contrast in Position y iff $y < x$.

If a language maintains rhotic duration contrast in heterorganic clusters, then it will also maintain contrast word-finally, and vice-versa. The all-or-nothing nature of contrast in these "elsewhere" contexts stems from the fact that they are targeted by a single CONTRAST(duration) constraint. In the next section, I show how articulatory markedness constraints may be ranked at different positions along the hierarchy in (1.28d), thereby generating different word-level patterns of contrast and neutralization.

1.3.2 Articulatory Markedness Constraints

The principal articulatory difference between the coronal tap and trill is that the former involves a ballistic gesture consisting of rapid approach and release transitions, while the latter is a held posture upon which passive vibrations are imposed by the airstream. The analysis developed here assumes two families of markedness constraints that refer to the articulatory representation of rhotics. The *FAST constraints in (1.30a–c) below are violated by the rapid transition phases of the coronal tap, more so in homorganic clusters and in phrase-initial position, as guaranteed by the positional markedness constraints in (1.30a) and (1.30b), respectively. On the other hand, the *HOLD constraint in (1.31) is violated by the longer constriction duration of the coronal trill.

(1.30) Markedness constraints against coronal tap

- a. *FAST/SAME SITE
Avoid faster-than-usual articulatory transitions in Place-sharing clusters involving the tongue tip
- b. *FAST/INITIAL
Avoid faster-than-usual articulatory transitions in phrase-initial constrictions involving the tongue tip
- c. *FAST
Avoid faster-than-usual articulatory transitions in constrictions involving the tongue tip

(1.31) Markedness constraint against coronal trill

- *HOLD
Avoid longer constrictions involving the tongue tip

In Chapter 3, I offer a more formal account of the effects that the above markedness constraints have on the articulatory realization of the tap and trill.

1.3.3 Typology of Constraint Rankings

One of the central claims of OT is that variation across languages follows from constraint ranking. Specifically, a typology of predicted grammars constitutes the set of distinct grammars predicted by different rankings of the same set of constraints. In this section, I show how the generalizations regarding neutralization in (1.2) stem from the interaction among CONTRAST(duration), *FAST, and *HOLD constraints.

First, the fact that intervocalic contrast is maintained in all of the languages surveyed stems from the dominance of CONTRAST(dur/V_V) over the markedness constraints with which it interacts, namely *FAST and *HOLD, as shown in (1.32):

(1.32) Constraint ranking affecting intervocalic position

CONTRAST(dur/V_V)	<i>Intervocalic contrast:</i>
	<i>in all languages surveyed</i>
*FAST,	
*HOLD	

While the lower-ranked constraints of the CONTRAST(dur) hierarchy may be dominated by relevant markedness constraints, the highest-ranked CONTRAST(dur/V_V) is always undominated in languages that have a contrast between the coronal tap and trill.

Otherwise, there would be absolute neutralization of the contrast, and the surface realization of rhotics would be determined solely by markedness.

Second, word-initial position typically either maintains contrast or exhibits neutralization to trill. This follows from the high ranking of CONTRAST(dur/#_V) in the former case and of *FAST/INITIAL in the latter, as shown in (1.33):

(1.33) Constraint rankings affecting word-initial position

- | | | |
|----|---|---|
| a. | CONTRAST(dur/#_V)

*FAST/INITIAL,
*HOLD | <i>Word-initial contrast:</i>
<i>Kaliai-Kove, Palauan, Kairiru, Ngizim</i> |
| b. | *FAST/INITIAL

CONTRAST(dur/#_V),
*HOLD | <i>Word-initial trill:</i>
<i>Basque, Iberian Romance, Kurdish</i> |

Now, when *HOLD outranks CONTRAST(dur/#_V), it also outranks—by transitivity of constraint ranking—the context-free CONTRAST(dur), as shown in (1.34):⁶

(1.34) Constraint ranking affecting non-intervocalic positions

- | | |
|---|--|
| *HOLD

CONTRAST(dur/#_V),
*FAST/INITIAL

CONTRAST(dur),
*FAST | <i>Non-intervocalic tap:</i>
<i>Sebei</i> |
|---|--|

This ranking captures the third generalization regarding neutralization, namely that word-initial tap entails taps also in heterorganic clusters and word-finally. In contrast, word-initial trill does not entail obligatory trills in heterorganic clusters nor word-finally. In the ranking in (1.33b), the positional constraint *FAST/INITIAL ensures word-initial trills, but

⁶ Although the positional *FAST/INITIAL is shown to dominate the context-free *FAST in (1.34), their ranking is actually irrelevant. As long as *HOLD is dominant in the hierarchy, the effects of these two lower-ranked *FAST constraints will not be seen. That is to say, the rankings of *HOLD » *FAST/INITIAL » *FAST and *HOLD » *FAST » *FAST/INITIAL are non-distinct in that both yield the same result, namely taps in word-initial position, in heterorganic clusters, and in word-final position.

nothing prevents lower-ranked *FAST from interacting with the other context-free constraints *HOLD and CONTRAST(duration), thereby generating different patterns in heterorganic clusters and word-finally.

Fourth, neutralization treats word-final position and heterorganic clusters as a natural class. Three scenarios are possible for these positions, as determined by the rankings of the context-free constraints in (1.35):

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

- | | | |
|----|---------------------------------------|---|
| a. | CONTRAST(dur)

*HOLD,
*FAST | <i>Contrast:</i>
<i>Kairiru, Kurdish, Ngizim</i> |
| b. | *HOLD

CONTRAST(dur),
*FAST | <i>Neutralization to tap:</i>
<i>Iberian Romance, Sebei, Palauan</i> |
| c. | *FAST

CONTRAST(dur),
*HOLD | <i>Neutralization to trill:</i>
<i>Basque, Kaliai-Kove</i> |

The facts involving neutralization in Iberian Romance are somewhat more intricate than suggested by the ranking in (1.35b). Chapter 3 examines Iberian Romance languages with alveolar trills, focusing in detail on neutralization in clusters and in word-final position.

The final generalization is that contrast is never allowed in homorganic clusters, where neutralization to trill is obligatory. This follows from the ranking of *FAST/SAME SITE above the other context-free constraints, shown in (1.36):

- (1.36) *FAST/SAME SITE *Neutralization to trill:*
 | *Iberian Romance, Kairiru, Ngizim*
 CONTRAST(dur),
 *HOLD

The ranking (1.36) is assumed to hold for all the languages of the rhotic duration typology, although its effects are not visible in languages where rhotics do not surface in Place-sharing clusters.

1.4 Overview of Dissertation

In Chapter 2, I examine the distribution of rhotics in Spanish and assess previous accounts of this pattern. Data are presented from other languages in order to identify the inadequacies of existing syllable-based approaches. Chapter 3 motivates and develops the phonetically-based OT account, with Spanish serving as the primary example. In Chapter 4, I demonstrate the empirical adequacy of the analysis with respect to the other languages of the typology. Finally, Chapter 5 examines issues of representation by focusing on the ambiguous nature of the surface trill, which behaves as a single phonological unit in some languages and as a cluster in others. The final chapter then concludes the dissertation with a summary of main results and some directions for future research.