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Licensing and Underspecification in Optimality Theory

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This article seeks to resolve one sort of underspecification paradox, by harnessing the notions of constraint ranking and violability provided by Optimality Theory (OT). Though output underspecification is maintained, it does not pattern in the all-or-nothing way predicted by known theories; further, it is an emergent property of the grammar, leading to rejection of the traditional reliance on feature minimization in underlying representations, a notion that is not compatible with OT's output-oriented perspective. The empirical focus is on nasal-obstruent (NC) voicing in Japanese; major issues addressed include feature licensing, the hypothesis that segment similarity constrains feature interaction, and the relation between output forms and underlying representations.

Keywords: Optimality Theory, licensing, underspecification, postnasal voicing, lexicon optimization, segment similarity

1 Introduction

It is a common observation that redundant phonological features are mostly inert, neither triggering phonological rules nor interfering with the workings of contrastive features. Consider redundant sonorant voicing versus distinctive obstruent voicing: in languages enforcing a ban on multiple occurrences of [voice] within certain domains—Japanese, or Proto-Indo-European (in the ''standard'' reconstruction; see Hayward 1989:45, Gar-

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rett 1991:793–803)—this constraint manifests itself in the fact that a voiced obstruent never cooccurs with another voiced obstruent (within the same root). Such voicing constraints leave sonorants unaffected: although voiced, they freely cooccur with each other and with voiced obstruents; their redundant voicing is apparently invisible to the constraint.

This link between phonological contrastiveness and activity on the one hand and phonological redundancy and inactivity on the other has played a key role in modern phonology. In a variety of recent theoretical approaches (beginning with Kiparsky 1982; see Steriade 1995 for comprehensive references), phonological inactivity has been formally expressed as feature underspecification: unlike voicing in obstruents, voicing in sonorants is literally not specified in the phonology. This underspecification of redundant features holds of underlying representations and persists into the phonological derivation.

There can be little doubt that theories of underspecification, as developed over the last decade (whether "radical," "contrastive," or other), have brought a new depth of explanation to a number of areas of phonological analysis (e.g., morpheme structure constraints, harmony systems, assimilation, and dissimilation). Building on this notion of underspecification, Lexical Phonology developed a principled typology of phonological rules that went far beyond earlier models and found a natural place within a comprehensive view of the phonological grammar as a multilevel derivational system (see Kiparsky 1982 and subsequent works).

Although the concept of underspecification has thus played a pivotal role, some analysts have noted the existence of problems and paradoxes threatening the conceptual and empirical basis of underspecification theory. This point has been made forcefully by McCarthy and Taub (1992) regarding the (under)specification of the feature [coronal] in English consonants (as the default member of the contrastive consonantal place category): though several arguments for the underspecification of [coronal] have been adduced, based on facts of distribution (Yip 1991, Davis 1991) or assimilation (Avery and Rice 1989), numerous generalizations holding of coronals during the early derivation require reference to [coronal], and hence specification. The generalizations in question hold of the entire class of coronals, including both marked (e.g., [θ, š]) and unmarked (e.g., [t, s]) members. Here are two examples (see McCarthy and Taub 1992 for others): (a) all initial "coronalC + [yu]" sequences are prohibited in American English (*[θyu], *[tyu]) (Borowsky 1986); (b) any Obligatory Contour Principle–based account of the [ɨ]~∅ alternation found in the plural, possessive, and past tense suffixes in English (*hit*[s], *hide*[z], *kiss*[ɨz], *wish*[ɨz], etc.) must build on the agreement in both place and manner between the consonants in question, and hence presupposes that the feature [coronal] is specified in all coronals (Borowsky 1986, 1987). Though one might entertain some hope that such facts could be accounted for by judiciously ordering default specification of [coronal] between the relevant statements, such attempted ordering solutions are unlikely to have a principled basis, and it is not even obvious that they can meet the simple criterion of descriptive adequacy (ordering paradoxes, etc.).

The coronality problem calls [coronal] (and more broadly, radical) underspecification into question; in fact, it is precisely facts of this kind that have figured prominently in the argumentation for "contrastive" (or "restricted") underspecification theory (i.e., underspecification of redundant features, but not of default values of contrastive features; see Steriade 1987, Clements 1988, Mester and Itô 1989). Further reflection and investigation reveal, however, that the demarcation line between phonologically active features and phonologically inactive features does not fall precisely where contrastive underspecification theory draws it; underspecification paradoxes involving only redundant features are not difficult to find (although they are hardly ever mentioned in the standard literature).

One case of this kind, involving nasals and [voice] in Japanese, was brought forth and discussed in the appendix of Itô and Mester 1986; in this instance the problem lies in the presence of redundant values in some contexts but not in others. In this article we reconsider these facts and show that such underspecification paradoxes are not minor problems, but rather result from an incorrect theory that views phonological constraints as absolute and inviolable well-formedness conditions, relativized in terms of individual grammars ("parameter settings") and to modules/levels within a grammar ("turning on/off"). In contrast, Optimality Theory (OT) (Prince and Smolensky 1993; see also McCarthy and Prince 1993), which we adopt in this study as a conceptual framework, holds that all phonological constraints are *uniformly present* in all grammars and at all levels, but are in principle *violable* (constraint violation is always minimal, within a grammar consisting of a hierarchy of ranked and violable universal constraints; see section 3 for a summary). Our general goal is to show how an optimality-theoretic conception of phonology overcomes some of the limitations of the traditional ways of treating redundancy and predictability and so breathes new life into the use of underspecification. In accordance with the output-oriented framework we adopt, conventional underspecification theory in the sense of legislation of feature minimization at underlying and intermediate representations is eschewed. But unlike attempts to simply do without phonological underspecification (and instead appeal to feature proliferation, visibility parameterization, or repair-and-rescue devices; see Calabrese 1994, Mohanan 1991, Steriade 1995, for various proposals), the theory developed here continues to grant a significant role to phonological underspecification—not as an input property but as an emergent *output* property enforced by feature-licensing constraints. Since there is no sequential phonological derivation in OT, there is also no sense in which (parts of) the phonological derivation could be characterized by underspecification. The resulting conception diverges significantly from the dichotomy between uniform specification and uniform underspecification that characterizes the standard theory. In optimality-theoretic terms, specification or nonspecification of a feature is just one aspect of the selection of the optimal output for any given input by the grammar; this selection depends on the structure of the input, and different results are possible, and indeed expected, for differently structured inputs. Specificational uniformity across all outputs at a certain level is not an operative consideration.

As further goals of the article, we hope to shed some light on the properties of postnasal voicing and of rules spreading redundant features in general, develop a notion of *feature licensing,* and provide insights into the workings of OT itself, focusing on issues related to lexicon optimization and constraint family dispersion.

This article is structured as follows. After a presentation of the nasal voicing problem (section 2), we develop an optimality-theoretic conception of feature licensing, illustrating and motivating it by means of an analysis of Japanese nasal-obstruent (NC) voicing (section 3). We turn next to some issues regarding input feature specification and lexicon optimization (section 4) and take up questions related to multiple linking (section 5), developing our analysis along the way. We conclude the article with a summary of the main results and a discussion of a number of open issues (section 6).

2 The Problem: Voicing and Nasals in Japanese

Japanese exhibits a morphophonemic alternation known as Rendaku (''sequential voicing''): under compounding, as in (1), an initial obstruent in the second member becomes voiced (Martin 1952:48–49, McCawley 1968:86–87). The alternation is confined to the Yamato (native) stratum of the lexicon and, though productive, has lexical exceptions. In the terminology of classical Lexical Phonology (e.g., Kiparsky 1985), Rendaku has all the characteristics of an early lexical process.

(1) a.	ori **k**ami	→	ori + **g**ami	'paper folding'
b.	oo **s**umoo	→	oo + **z**umoo	'grand *sumo* tournament'
c.	yama **t**era	→	yama + **d**era	'mountain temple'
d.	mizu **t**eppoo	→	mizu + **d**eppoo	'water pistol'
e.	mizu **h**ana (h</p/)	→	mizu + **b**ana	'running nose'

Itô and Mester (1986:71–72) provide an analysis of Rendaku as an autosegmental [voice] morpheme that is realized at the left edge of the second member. On this basis, the analysis derives the phonological characteristics of the voicing morpheme from general principles of phonological well-formedness like the Obligatory Contour Principle (OCP; Leben 1973, McCarthy 1986).[1] The key observation about Rendaku concerns its interaction with a constraint on Yamato roots prohibiting more than one voiced obstruent per root (i.e., there are no forms like **dabi,* **gugi*). This interaction, known as Lyman's Law, manifests itself in the obligatory absence of Rendaku voicing in forms like those in (2), where the second member already has an underlying voiced obstruent. The OCP holding over the [voice] tier provides a unified explanation both for the morpheme-structural fact that there are no roots like **dabi* and for the derivational fact that Rendaku voicing is blocked in *širo-tabi* (**širo-dabi*) (see Itô and Mester 1986 for details of the analysis).

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[1] The morphosyntactic distribution of the voicing morpheme is an entirely separate issue; besides morpheme class (Yamato vs. non-Yamato), the argument structure of the whole compound plays a decisive role in this context (see Uribe-Etxebarria 1992 for recent discussion).

(2) a.	širo + ta**b**i	‘white tabi’	*širo + **d**a**b**i
b.	ore + ku**g**i	‘broken nail’	*ore + **g**u**g**i
c.	mono + šizuka	‘tranquil’	*mono + **ǰ**izuka
d.	maru + ha**d**aka	‘completely naked’	*maru + **b**a**d**aka

Of special interest here is the fact that sonorants do not behave like voiced segments for the purposes of Lyman’s Law: neither vowels nor sonorant consonants (see (1)) exert any blocking effect on Rendaku voicing. Examples like those in (3) make the additional point that voiceless segments are transparent to Lyman’s Law: the blocking effect of a voiced obstruent extends across voiceless segments to the left edge of the domain.

(3) a.	onna + **k**o**t**o**b**a	‘feminine speech’	*onna + **g**o**t**o**b**a
b.	ko + **h**i**ts**u**ǰ**i	‘child lamb’	*ko + **b**i**ts**u**ǰ**i

Underspecification theory establishes a link between redundancy, unmarkedness, and phonological inactivity. Under any conception, the redundancy of [voice] in sonorants entails the underlying absence of such [voice] specifications. The transparency of voiceless obstruents follows either from the absence of (unmarked) [−voice] in obstruents along the lines of radical underspecification theory (Kiparsky 1982, Archangeli 1984, Itô and Mester 1986, among others) or from the nonexistence of this value in privative voicing theory (Trubetzkoy 1939, Steriade 1987, Mester and Itô 1989, Cho 1990, Lombardi 1991, among others). The OCP effect over [voice] will therefore obtain as indicated in (4) (we are using “v” to abbreviate [voice] and “ǂ” to express nonassociation).

```
(4)  onna  +  kotoba
              ǂ   |
              v   v
```

The facts seen so far provide strong support for the underspecification of redundant features (here, [voice] in sonorants). A second constraint holding of Yamato forms illustrated in (5) requires all nasal-obstruent (henceforth, NC) clusters to be voiced throughout.

(5) a.	to**mb**o	‘dragonfly’	cf. *to**mp**o
b.	ši**nd**o-i	‘tired’	*ši**nt**oi
c.	u**nz**ari	‘disgusted’	*u**ns**ari
d.	ka**ŋg**ae	‘thought’	*ka**ŋk**ae

We state this constraint informally in (6).

(6) A nasal must share the feature [voice] with a following consonant.

Speaking procedurally, nasals spread [voice] to a following obstruent. This not only holds as a morpheme structure constraint, as illustrated in (5), but also is instantiated in alternations, as seen in examples involving gerundive *-te* in (7).

(7) a. /yom + te/ → yonde 'reading'
b. /šin + te/ → šinde 'dying'

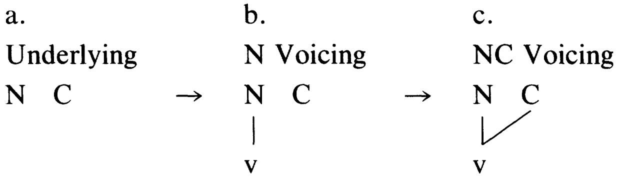
There is no comparable voicing after other sonorants, either after vowels (8a) or after other nonnasal sonorant consonants like *r* (8b–c).[2]

(8) a. /mi + te/ → mite 'seeing'
b. /tor + te/ → totte 'taking'
c. /kaw + te/ → katte 'buying'

The basic analysis of NC voicing in Itô and Mester 1986:69–71 takes a standard view of such facts (see Kiparsky 1982). In brief:

- The redundant [voice] of nasals is underspecified (9a).
- At some point during the phonological derivation, nasals receive [voice] (9b).
- [voice] spreads rightward (9c) by means of a rule independently necessary within the analysis.

(9) *NC Voicing*



However, Itô and Mester (1986:69–71) also show that these assumptions lead to an underspecification paradox, a point later taken up by Borowsky (1986:34) and Taub (1988). Nasals (together with other sonorants) must *not* be specified for [voice] when Rendaku and Lyman's Law apply, as seen in (1). This implies that Rendaku and Lyman's Law must take place before the assignment of redundant [voice] to nasals (9b). By transitivity, NC Voicing (9c), which must follow (9b), should also not be visible to Lyman's Law. However, the facts show the opposite: NC Voicing *is* visible to Lyman's Law and blocks Rendaku, as illustrated by compounds like *širooto-ka**ŋg**ae* 'layman's idea' (10) (**širooto-ga**ŋg**ae*).

(10) *The underspecification paradox for serial derivations*: haya-gane *'fire bell' vs.* širooto-kaŋgae *'layman's idea'*

a.	Underlying	/haya + kane/	/širooto + kaŋkae/
	Rendaku	haya + **g**ane	širooto + **g**aŋkae
	N&NC Voicing	haya + gane	širooto + ga**ŋg**ae
	Output	**✓haya + gane**	*širooto + gaŋgae

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[2] Clusters of the form {*w*/*r*} + *C* are syllable-structurally impossible in Japanese, but they do arise underlyingly in the verbal morphology, as shown in (8b–c).

b.	Underlying	/haya + kane/	/širooto + kaŋkae/
	N&NC Voicing	haya + ka**n**e	širooto + ka**ŋg**ae
	Rendaku	(blocked by OCP)	(blocked by OCP)
	Output	*haya + kane	✓**širooto + kaŋgae**

The derivations in (10) bring out the contradiction by contrasting a form containing a plain medial nasal, which requires Rendaku to precede N Voicing (10a), with a form containing a medial NC cluster, which requires the opposite order (10b). We have, then, a paradox: nasals in NC clusters must be specified for [voice] just when other nasals must not be. A general approach invoking a redundancy rule [+nasal] → [+voice], whether by stipulation to a domain or by the Redundancy Rule Ordering Constraint (Archangeli 1984, Archangeli and Pulleyblank 1986), fails because it paints with too wide a brush, requiring that *all* nasals receive [voice], if any do. Instead, nasals appear to receive [voice] only where necessary to trigger NC Voicing. We could of course encode this fact in the redundancy rule itself, by making the presence of a following obstruent a condition on the insertion of [voice]. Such a solution is little more than a statement of the problem, since it remains a coincidence that insertion takes place just in the context where another rule will later apply to spread [voice] onto the following consonant. (Why not insert [voice] on final nasals? Or on nasals before high vowels? etc.) As a minimal condition of adequacy, we require that the analysis attempt to establish some relation between the NC voicing phenomenon and the presence of redundant [voice] in N.

In response to this problem, Itô and Mester (1986) propose a level-ordered solution, in which nasal voicing is inserted at a level prior to other sonorant voicing, noting at the same time that this proposal, although descriptively adequate, has serious drawbacks and in any case cannot serve as a general answer to underspecification paradoxes. An interesting new idea is proposed by Borowsky (1986:34), who relies on an unorthodox assumption about the feature structure of linked NC clusters. Although the account succeeds in deriving the postnasal voicing facts without additional machinery, Taub's (1988:70–73) comprehensive discussion shows that the paradox itself still remains. However, one of the central ingredients of Borowsky's account—the idea of relating postnasal voicing to segment markedness conditions (nasals must be voiced, and obstruents can accommodate voicing)—is preserved, albeit in a different form, in our optimality-theoretic account below. Other proposals have tried to circumvent the paradox by splitting the distinctive feature [voice] into several subfeatures that can be separately appealed to (see Rice 1993 for [spontaneous voicing], Steriade 1995 for [expanded pharynx]). But precisely because such analyses differentiate in a fundamental way between sonorant and obstruent voicing, voicing *interactions* between the two segment classes, as in NC voicing, come as a surprise, to be accommodated by special mechanisms (see section 6 for further discussion). We will argue that the trouble lies not with [voice], but with the traditional view of the organization of phonology; and the challenge is to resolve the paradox without destroying the unity and integrity of the distinctive feature [voice].

Taking a fresh look at the problem, the solution to be developed builds on an understanding of redundant feature (under)specification in terms of *licensing,* advanced in the setting of OT. This solution, although conceptually very different and with somewhat different empirical consequences, shares one crucial point with the earlier analysis of Itô and Mester (1986). It relies on the fact that within specific grammars, general constraints can be decomposed into a *family* of separate, more specific conditions: nasal voicing can be separated from other sonorant voicing (cf. the similar decomposition of [ATR]/height constraints for vowels in Archangeli and Pulleyblank 1994), employing a notion of what we will refer to as *constraint family dispersion* (first proposed in Prince and Smolensky (henceforth PS) 1993).

3 Feature Licensing and Redundancy

3.1 Background on Optimality Theory

The basic tenets of Optimality Theory that will be important to our theory of feature licensing are constraint-based output selection, constraint universality and ranking, and the principle of minimal violation (see PS 1993 for a comprehensive and more formal presentation, as well as McCarthy and Prince 1993, 1994a, and references therein for further details).

Constraint-based output selection. The output of phonology or morphology is determined by well-formedness constraints that select among some candidate set of forms (based on some underlying representation as input), considered in parallel. As a result, there are no rules or repair strategies, and no serial derivation. Candidate sets are in principle infinite and maximally inclusive, leaving the job of winnowing out forms to the well-formedness constraints.

Universality and ranking. The set of constraints $\mathbb{C}$ is provided by Universal Grammar ($\mathbb{C} = \{C_1, C_2, \ldots, C_n\}$); an individual grammar **G** is obtained by imposing a strict dominance order $\gg$ on the elements of $\mathbb{C}$ ($\mathbf{G} = (\mathbb{C}; \gg)$). In the standard conception, the relation $\gg$ is a strict linear order (i.e., it is total, transitive, and asymmetric): for any two constraints C_i and C_j, either $C_i \gg C_j$ or $C_j \gg C_i$, but not both; and if $C_i \gg C_j$ and $C_j \gg C_k$, then $C_i \gg C_k$.[3] The well-formedness constraints in $\mathbb{C}$ form the substance of some part of theoretical phonology (prosodic phonology, feature geometry, the theory of autosegmental operations, etc.).

Minimal violation. All constraints are in principle violable. Ranking and violability are the key characteristics of OT that set it apart from other conceptions of grammar (like the Minimalist Program outlined for syntax in Chomsky 1993). In particular, these concepts are not found in other nonderivational constraint-based theories of phonology, such as Harmonic Phonology (Goldsmith 1990, 1991, 1992) and Declarative Phonology

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[3] It is conceivable that these restrictions on $\gg$ should be loosened in some respects (e.g., from a total to a partial order); see PS 1993 for discussion.

(Scobbie 1991) (though see Paradis 1988a,b for a different kind of constraint violability and constraint ranking in derivational terms; see PS 1993:214–219 for discussion). And arguably these two properties of ranking and violability are the crucial elements responsible for the theory's explanatory successes, not only in phonology, but also in other areas of grammar, including prosodic morphology (McCarthy and Prince 1993), allomorphy (Mester 1994), and syntax (Grimshaw, to appear).

As noted, the output of an optimality-theoretic grammar is not the result of a derivation, as in standard phonological theorizing. Rather, phonological adjudicating proceeds in parallel: every possible candidate is considered for a given input form.[4] The actual output form—the optimal form—is the (often, but not necessarily, unique) member of the candidate set that best satisfies the constraint hierarchy. We will show in section 4, with concrete examples, how ''best-satisfaction'' can be determined in a straightforward way for tableau representations of candidate sets (see PS 1993:68–76 for a formal definition in terms of harmonic ordering).

This sketch of OT is incomplete in various respects, but it is sufficient to set forth our basic hypotheses about redundancy and underspecification, which are intrinsically linked to a conception of constraints as ranked and violable. Our goal is to explain the specificational behavior of redundant features (like [voice] in nasals) as the result of the antagonistic interaction of two families of constraints, one favoring richness of phonetic specifications, the other favoring the opposite. Both groups of constraints are part of the dominance hierarchy that constitutes the grammar of a language.

On the one hand, there are the familiar phonetic-realizational constraints (involving ''grounding,'' in the terminology of Archangeli and Pulleyblank 1994), where representations are required to be richly specified for phonetically required or desirable properties. These include the redundant properties for each segment class; they may be physically inherent, or serve to enhance contrasts, or in other ways be favored (see Stevens, Keyser, and Kawasaki 1986). Thus, sonorants are voiced, back (nonlow) vowels are round, high vowels are [+ATR], and so on.

On the other hand, there is the world of feature minimization and distinctiveness: languages are parsimonious with respect to inventory, building on a few operative phonetic distinctions. The many other distinctions that form part of the spectrum of universal phonetic capabilities of humans play no role in the organization of the inventory.

These two factors—one favoring specificational abundance, the other favoring specificational parsimony—are antagonistic. Standard underspecification theories, with their apparatus of feature minimization, marking conventions, default and redundancy rules, orderings, and so on, can be viewed as particular ways of adjudicating between them. Faced with antagonistic principles, a theory subscribing to the view that grammatical

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[4] As PS (1993:197–198) note, this kind of infinity is no great liability; a theory of grammar requires that the notion ''best-satisfactor'' be well defined, *not* that it be constrained by a priori notions of computability. Furthermore, the sources of infinity are few in number (mainly epenthesis, the insertion of nonunderlying material) and can be controlled by a suitable heuristic.

constraints are always inviolable at their point of application only has the option of assigning the two antagonistic principles different parts of the derivation (early vs. late) as their respective domains, such that each of them can hold true within its particular domain. It is this attempt to find the solution in derivational differentiation that leads to underspecification paradoxes.

OT, on the other hand, can adjudicate between the two kinds of constraints by ranking them directly with respect to each other, without having to create a special derivational stage or level during which redundant features are absolutely prohibited. A crucial aspect of our solution to the feature specification problem is that it builds on a small group of simple constraints, all independently motivated and plausible candidates for Universal Grammar.

3.2 Underspecification as an Output Property

Consider the connection, often merely implicit in practice and yet clear in principle, between feature redundancy and feature underspecification. Building on a proposal made by Padgett (1991:56–58), we link the two by means of the notion *licensing*. The hypothesis formulated in (11), as a principle of Universal Grammar, is an explicit statement of this connection (cf. the redundancy rules and marking conditions of Kiparsky (1985), Archangeli and Pulleyblank (1986), and others).

(11) *Licensing Cancellation*

If $F \supset G$, then $\neg(F \lambda G)$.

"If the specification [F] implies the specification [G], then it is not the case that [F] licenses [G]."

The statement in (11) is intended as follows: Suppose a grammar contains a segment structure condition expressing the segment-internal redundancy that a segment that has the feature [F] also has the feature [G]. Then the feature [G] is not licensed within a segment containing [F]. For example, given the redundancy implication [sonorant] ⊃ [voice], a sonorant segment does not license [voice]. The [voice] feature is licensed when linked to obstruents (12a), but not when linked to sonorants (12b).

(12) a. *Licensed [voice]* b. *Unlicensed [voice]*

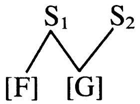
[d] [n]

| |

[voice] [voice]

Our use of the notion "license" and of Licensing Cancellation (11) differs in a crucial way from more familiar formulations in terms of cooccurrence statements like *[F, G] (e.g., *[sonorant, voice]). Unlike the latter constraint, Licensing Cancellation does not imply any *incompatibility* between the two features. The difference can be best appreciated in a scenario like the one in (13), where both segments S_1 and S_2 are specified for [G], but only S_1, and not S_2, is specified for [F].

(13)



Given (11), S_1 does not license [G]. [G] is nevertheless licensed—by S_2, as long as S_2 contains no feature, [F] or other, that implies the presence of [G]; therefore, the representation is well formed. On the other hand, [G] would violate a constraint *[F, G], regardless of any double linking. This use of licensing (also see Steriade 1995 on "indirect licensing") extends to the featural domain licensing accounts familiar from other areas, such as coda linking (Goldsmith 1990, Itô and Mester 1993, Lombardi 1991, building on Itô 1986, 1989; also see Borowsky 1986, Hayes 1986, Schein and Steriade 1986).

Licensing cancellations define special situations that contrast with the default scenario where all features properly incorporated into feature-geometrical representations are licensed. Thus, [voice] linked to an obstruent root, where no redundancy condition leads to a cancellation of licensing, is ipso facto licensed (12a). The relationship between general feature licensing and particular licensing cancellations is an example of the general case/special case scenario familiar from the Elsewhere Condition (Kiparsky 1973) as well as more recent work in OT (the "Pāṇinian relation" of PS 1993).

Thus, given Licensing Cancellation, a redundancy implication [sonorant] ⊃ [voice] means that the feature [voice] is not licensed in a sonorant segment (12b). The absence of [voice] is forced by the relevant member of the family of feature-licensing constraints schematically characterized in (14).

(14) *License(Φ)*
The phonological feature Φ must be licensed.

In the context of our discussion, the relevant redundancy implication in Japanese (shared by all natural languages) is the one repeated in (15) (we follow the convention in OT of abbreviating constraint names for use in constraint tableaux). This condition in fact represents a whole family of sonorant-voicing conditions (governing nasals, liquids, vocoids, and other sonorants).

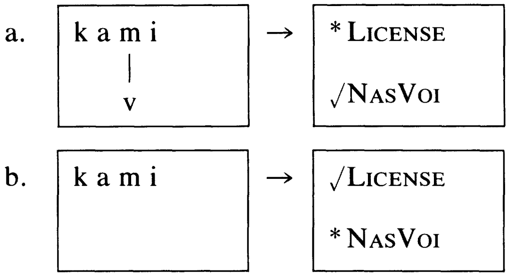
(15) *SonVoi*
[sonorant] ⊃ [voice]

To illustrate the role of feature licensing in our account of Japanese, we will use the word *kami* 'paper'. The relevant members of the constraint families involved are the voice-licensing constraint License(Voice) (16), where Φ = [voice], and the nasal version of the sonorant-voicing condition NasVoi (17).

(16) *License(Voice)*
The feature [voice] must be licensed.

(17) *NasVoi*
[nasal] ⊃ [voice]

Since License(Voice) is the only member of the family of licensing constraints to play a role in our analysis, we will refer to this constraint simply as License. Focusing on the nasal [m] in *kami,* we have two potential candidate representations: one with the nasal specified for voicing (18a), and one with the nasal unspecified (18b).

(18)


(18a) fulfills NasVoi but violates License. (18b), on the other hand, violates NasVoi but fulfills License. The situation thus looks like a standoff, with each representation violating one constraint, while fulfilling the other. This is the kind of constraint conflict that OT resolves, with its notion of constraint domination (recall section 3.1). Leaving details to the more technical expositions of the formal theory (see especially PS 1993), the central idea is that constraints are ranked in a strict domination order, with higher constraints taking absolute precedence over lower constraints. For the case at hand, we hypothesize that License is ranked above NasVoi. In the notation of OT, this is written as in (19).

(19) License ≫ NasVoi

Given this constraint ranking, (18b) is the winning candidate, with the nasal unspecified for voicing. The OT-style tableau 1 illustrates the crucial ranking graphically in terms of columns ordered from left to right. In tableaux, a "*" in row *i,* column *j* indicates that candidate *i* violates constraint *j*. Candidate (b) in tableau 1, for example, violates License. Evaluation of the candidates proceeds recursively by constraint, until all candidates besides the winning one are eliminated. In this simple case, the decision is already reached in the first round. "*!" denotes the crucial failure of a given candidate. Here is the sense in which there are no trade-offs: even the most splendid fulfillment of subordinate constraints cannot rescue a candidate that has slipped with respect to a higher-ranking constraint in the eyes of the theory. In this way, the winning candidate emerges as optimal, a status denoted by the pointing hand (☞). The optimal candidate is the only well-formed candidate and is selected as the output. All other candidates are ill formed.

Tableau 1

<table>
<tr><th></th><th>Candidate</th><th>License</th><th>NasVoi</th></tr>
<tr><td>a. ☞</td><td>k a m i</td><td></td><td>*</td></tr>
<tr><td>b.</td><td>k a m i
|
v</td><td>*!</td><td></td></tr>
</table>

Though violations after critical decision points are recorded for completeness, these results have no bearing on the outcome, a fact indicated by shading of the corresponding cells.

The constraint configuration in tableau 1 is the core of our proposal in this article, which will be fleshed out in crucial respects as we proceed. In general (with one important exception, to be discussed below), it settles exactly on the degree of feature (under)specification amply supported in past work on Japanese phonology and elsewhere. More concretely, the representation in (a) of tableau 1 is the empirically justified underspecified representation for Rendaku and Lyman's Law, as we have shown: [m] does not carry [voice]; hence, Rendaku voicing is not blocked and applies to the initial [k] in (20a).

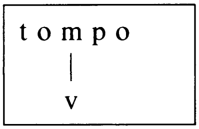
(20) a. ori kami → ori + **g**ami, *ori + **k**ami 'folding paper'
b. nise kagi → *nise + **g**agi, nise + **k**agi 'fake key'
c. ao kaki → ao + **g**aki, *ao + **k**aki 'green persimmon'

In contrast, a form like *kagi* 'key' (20b), with distinctive voicing on /g/, does not have the unspecified representation. The fact that [voice] is distinctive for obstruents means that there cannot be a redundancy condition for obstruent voicing (since the unpredictable cannot be predicted). Consequently, Licensing Cancellation does not take effect, and the voicing on the medial /g/ fulfills License (21a). NasVoi is vacuously satisfied since the form has no nasal segment. The voicing feature licensed by the medial obstruent [g] manifests itself by blocking Rendaku voicing in (20b). The medial obstruent in *kaki* 'persimmon' (20c) likewise satisfies License and NasVoi (21b).

(21) a. k a g i → √ License
|
v √ NasVoi

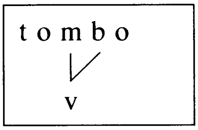
b. k a k i → √ License
√ NasVoi

Turning now to the postnasal voicing facts presented in section 2, we have to account for the fact that there are (Yamato Japanese) roots like *tombo* 'dragonfly', but no roots like **tompo,* and for alternations like /yom + te/ → *yonde,* not **yonte*. Focusing on the NC cluster (and abstracting away from place assimilation), consider first the following two candidates that are parallel to (18):

(22) a.  → * License √NasVoi

b. tompo → √License * NasVoi

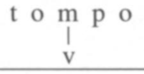
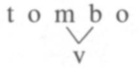
Everything else being equal, the same reasoning that applied to (18) should lead to the conclusion that (22b) is superior. Not everything is equal, though, since in this case there is another relevant candidate (23), with doubly linked voicing.

(23)  → √ License √ NasVoi

The feature [voice], though not licensed by the nasal Root node, is here licensed by the obstruent Root node and hence fulfills License. This last candidate representation, which fulfills both licensing and the redundancy condition that nasals should be voiced, is therefore superior to both of the representations in (22), each of which respects only one of the conditions. This is more perspicuously brought out in tableau 2.

Recall in what respect feature licensing differs from statements like *[nasal, voice]: in our terms, the nasal segment is in no sense incompatible with linked [voice]. Rather,

Tableau 2

	Candidate	License	NasVoi
a.	tompo		* !
b.		* !	
c. ☞			

it merely fails to grant licensing; such licensing however is conferred by the obstruent Root node. Feature licensing explains why only doubly linked NC nasals are (redundantly) voiced. In its crucial rejection of the notion that a voicing condition like NasVoi has no force at all at some early "level" of the phonology, this picture of underspecification is specific to an account in the spirit of OT.

In the absence of evidence to the contrary, we assume that License is undominated. Given the possibility envisioned within OT of deriving new grammars by reranking constraints, we might expect to find some language with the ranking NasVoi ≫ License, which entails redundant [voice] specification. (We might similarly find such a ranking between any redundancy condition and the related licensing condition, in Japanese or elsewhere.) However, the issue is complicated by an evident need for a theory of *ranking markedness* itself, given the existence of apparently robustly undominated constraints across languages (see, e.g., PS 1993, McCarthy and Prince 1993).[5]

The result of the considerations in this section is that feature-spreading configurations are advantageous: clusters doubly linked for [voice], such as Yamato Japanese NC clusters, are optimal because they simultaneously fulfill both constraints—feature licensing and the nasal-voicing condition. Everything else being equal, no representation fulfilling only one of these constraints while violating the other one could be superior.

But is everything else truly equal? What is the cost exacted by feature spreading itself, compared to representations without the extra associations? In most rule-based theories of phonology, feature spreading is ascribed to the operation of a phonological rule; spreading is not "automatic" (see Pulleyblank 1986 for an extended argument to this effect). It seems reasonable to hypothesize, then, that multiply linked configurations must exact some price. How should the extra association lines be counted, and how should these marks be weighed against the marks incurred for other constraints?

Such questions are important not just for the particular analysis being pursued here, but for a proper understanding of OT itself as a general theory of phonology extending beyond prosodic phonology (syllable and foot parsing, etc.) into the area of (auto)segmental phenomena, where spreading and delinking have figured very prominently in past analyses. Seeking an answer to these questions, in the next section we develop the standard theory of faithfulness constraints and explicate the nature of inputs in a theory that adopts a principle of lexicon optimization (PS 1993).

4 Input-Output Disparities: Faithfulness and Lexicon Optimization

In OT much of the role of the traditional phonological derivation, as a sequence of operations modifying inputs in a step-by-step fashion, is taken over by the Generator (Gen). Roughly speaking, the results of phonological operations are included in the vast

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[5] Given the presence of redundant specifications in the phonetic output (e.g., voicing of [m] in *kami*), any account of Japanese necessarily distinguishes the phonological and phonetic levels. Pursuing this point, we might suppose that phonetics differs from phonology in that License is lower on the constraint hierarchy in the former. Although such statements capture an intuition about the phonology/phonetics distinction, it remains to be seen whether it is reasonable to employ the vocabulary of OT itself with reference to phonetics.

class of "improvisations" that Gen produces for a given input as the associated candidate set, which is then evaluated by the constraint hierarchy of a particular grammar. Central to an enterprise of this kind are constraints that regulate input/output disparities. This role falls to the constraints PARSE and FILL introduced in PS 1993, known collectively as the FAITHFULNESS family of constraints.

Faithfulness favors minimal deviation: PARSE militates against underparsing ("deletion": a failure to parse an input element in the output), whereas FILL militates against overparsing ("insertion": a failure to fill a phonological position with underlying material; i.e., the appearance of output elements that are not part of the input).[6] Since we are concerned here with elements at the featural level (and not just with whole segments) and with association relations between elements of feature structure, it is incumbent upon us to address the issue of faithfulness in a more general way. Faithfulness, understood as a ban on disparities between input and output, must cover both substance and structure. Besides macroelements like whole segments, faithfulness governs individual features as well as *association relations* between features.

Building on PS 1993 and on our earlier work in OT (Itô, Mester, and Padgett 1993), as well as that of others (McCarthy and Prince 1993, Myers 1993, Archangeli and Pulleyblank 1993),[7] we extend the faithfulness constraints as in (24). Since the individual constraints shown below need not be distinguished in the ranking hierarchy to be discussed, we group the family of faithfulness constraints into a single collective constraint FAITH.

(24) *FAITH (Feature Faithfulness)*

PARSEFEAT
All input features are parsed.

FILLFEAT
All features are part of the input.

PARSELINK
All input association relations are kept.

FILLLINK
All association relations are part of the input.

Gen can insert new structure/features, and fail to parse input structure/features, at the price of accruing FAITH violations. These constraints assign the cost corresponding

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[6] Here we follow PS (1993) in assuming that no element may be literally removed from the input: that is, Gen fulfills the condition that inputs are literally contained in all associated outputs (a monotonicity requirement dubbed *Containment* in McCarthy and Prince 1993:20). Hence the notion "failure to parse" (in contrast to removal of) an element. There are a number of alternative possibilities for encoding input-output relations in OT (see, e.g., Itô, Mester, and Padgett 1993; see also McCarthy and Prince 1994b for an explicit alternative theory using a correspondence relation holding between each output candidate and the input). As far as we can see, little, if anything, of the substance of our analysis and theory depends on the precise method of encoding input/output disparities, and we have here adopted the standard Containment view for ease of exposition.

[7] See also McCarthy 1993 for a somewhat different theory appealing directly to morphemic affiliation (MSEG).

Tableau 3

Input: /kaki/ ‘persimmon’

	Candidate	License	NasVoi	Faith
a. ☞	k a k i			
b.	g a k i *v*			*!
c.	k a g i *v*			*!
d.	g a g i *v* *v*			*!*

to an appeal to autosegmental operations like spreading, insertion, or deletion in a rule-based derivational analysis.

As we will presently show, Faith is dominated by License and NasVoi: consequently, Faith is violated under the pressure to fulfill one of these higher-ranking constraints. First we will demonstrate a more elementary role for Faith: this constraint militates against the sheer gratuitous insertion or deletion of a feature like [voice].

Consider first the form /kaki/ ‘persimmon’ in tableau 3, with two underlyingly voiceless obstruents. As members of the candidate set associated with this input, Gen submits the representations in tableau 3, with and without inserted [voice]. (Here and throughout, inserted features are italicized, and inserted links are dotted. The dashed line in the tableau indicates that there is no constraint-ranking argument regarding Faith so far.) All candidates fulfill the licensing condition and the redundancy condition (see (21)); and the candidate in (a) of tableau 3 that is faithful to the input wins.[8] In addition to the constraints depicted here, candidate (d)—with two inserted [voice] specifications—violates the OCP over [voice] (see section 2). On the other hand, given underlying /kagi/ ‘key’, candidate (a) of tableau 4—with a *voiceless* medial obstruent—is unfaithful, since it has left the underlying [voice] feature unparsed (indicated by crossing out). Thus, all else being equal, Faith makes the choice in favor of the candidate that remains faithful to the input.

---

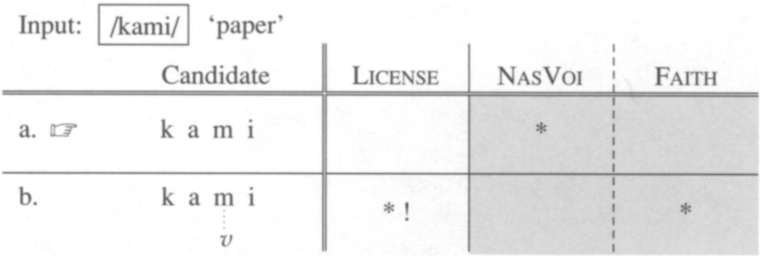
[8] For any FillFeat violation associated with a single FillLink violation (and similarly, for any ParseFeat violation associated with a single ParseLink violation), we have adopted the policy of including only one mark in the Faith column (see, e.g., (b) and (c) of tableau 3 and (a) of tableau 4). Besides aiding expository convenience, this practice avoids an unwarranted reification of association lines (see also the features-as-attributes view ascribed to Janet Pierrehumbert in McCarthy and Prince 1994b). The point of the Faith-Link constraints, as separate from Faith-Feat, is to militate against the establishment (or nonparsing) of *additional multiple* associations; see for example candidate (d) of tableau 7. In their focus on spreading configurations, Faith-Link constraints correspond to the *Spread constraint of Itô, Mester, and Padgett (1993).

Tableau 4

Input: /kagi/ ‘key’
|
v

	Candidate	LICENSE	NASVOI	FAITH
a.	k a k i + ~~v~~			* !
b. ☞	k a g i | v			

Tableau 5



Input: /kami/ ‘paper’

	Candidate	LICENSE	NASVOI	FAITH
a. ☞	k a m i		*	
b.	k a m i ⋮ *v*	* !		*

Let us now return to forms like *kami* ‘paper’. Assuming an input in which the nasal is unspecified for [voice], Faith would seem to interact in no interesting way with our analysis, as tableau 5 suggests. Underspecified /m/ again emerges as the winner; the voice-specified candidate only looks worse for the pointless insertion of unlicensed [voice].

Faithfulness considerations become more interesting, however, when we take into account alternative *input* representations. Suppose that the nasal is specified for [voice] *underlyingly*, as in tableau 6. For this input to surface with [voice] unspecified, as required for Japanese (as evidenced by the Rendaku/Lyman’s Law evidence in section 2; recall *ori-gami*, etc.), [voice] must go *unparsed*, in violation of Faith. This output, unfaithful to the input, is ensured provided Faith is outranked by License.

Traditional underspecificationism, with its input-focused feature minimization program, bans input representations like those in tableau 6. But within OT, this kind of legislation on inputs has no direct counterpart, and one is compelled to ask what, if anything, governs the degree of specification in input representations. The notion ‘‘underlying representation’’ takes on a somewhat new status in a theory in which the output is determined by the parallel consideration of (potentially limitless) candidate sets (see PS 1993:175–196). Central to the enterprise of OT is the hypothesis that explanation can be achieved through output constraints alone. Therefore, neither underspecification, nor

Tableau 6

Input: /kami/
|
v ‘paper’

	Candidate	License	NasVoi	Faith
a. ☞	k a m i + ~~v~~		*	*
b.	k a m i | v	* !		

anything else, can be meaningfully required of inputs (in any case, not directly; see PS 1993:49–51 for further discussion on MParse).

The strongest, and therefore most interesting, hypothesis is that output-focused constraints are not only necessary but also sufficient. This means that the grammar contains no separate constraint system governing inputs that could enforce a particular degree of (under)specification. Rather, in every case the output constraint hierarchy itself must be able to force the correct outcome, irrespective of the degree of input (under)specification.[9] Other views are certainly possible, but in the absence of any evidence warranting a more complex theory with an additional level of input constraints, the stronger hypothesis must be maintained. In our terms, underspecification effects are output effects and depend solely on the ranking License ≫ Faith. Underspecification, then, is an *emergent property of the output*. Whether redundant voicing is underlyingly present (tableau 6) or not (tableau 5), the outputs converge on the same *output core* (parsed substructure), with /m/ not linked to voice. (This argument is modeled on the approach to segment inventories in PS 1993:178–185.)

Consider now the constraint tableau 7, which evaluates candidates built on the input /tompo/ (for the Japanese form *tombo* ‘dragonfly’). As noted earlier, we assume the candidate set to include any autosegmental ‘‘improvisation’’ on the input—insertion and nonparsing of features, and so on. Since our focus is on the medial NC cluster and the feature [voice], we indicate only the presence or absence of relevant voicing specifications in the input and in the candidate forms. The two candidates (b) and (e) of tableau 7 fail for now familiar reasons, falling victim to License. Candidates (a) and (c) are eliminated by NasVoi. The doubly linked candidate (d) emerges as optimal—though violating faithfulness—since it satisfies both higher-ranked constraints. Here we see the crucial ranking of NasVoi ≫ Faith: were this ranking reversed, the faithful candidate (a) (having passed licensing) would emerge the winner. Instead, dominant NasVoi forces the insertion of [voice] and double linking, resulting in multiple violations of Faith. Thus,

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[9] It goes without saying that underlying representations by themselves continue to be crucial in determining the class of surface representations generated by a grammar for a given language: unpredictable lexical information is by definition irreducible.

Tableau 7

Input: /tompo/ 'dragonfly'

	Candidate	License	NasVoi	Faith
a.	tompo		*!	
b.	tompo ¦ v	*!		*
c.	tombo ¦ v		*!	*
d. ☞	tombo ⋁ v			**
e.	tombo ¦ ¦ v v	*!		**

postnasal voicing depends on the assumption that inserting and spreading [voice] costs less than violating the requirement that nasals be voiced.

Turning now to the question of *input* representations, we will use the same example and consider several alternative input representations for the Japanese form *tombo*. As potential alternative inputs, we choose the five representations in (25) identical to the *output candidates* (a–e) in tableau 7. Anticipating the main result, we will see that all of these possible inputs converge on an output core with double linking of [voice].

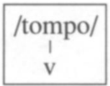
(25)	a.	b.	c.	d.	e.
	tompo	tompo	tombo	tombo	tombo
		|	|	⋁	| |
		v	v	v	v v

We have already evaluated the candidate set associated with input (25a) in tableau 7. Below we establish that double linking for [voice] is the fate of all the other inputs as well. This result follows from the fact that Faith is outranked by both License and NasVoi. The latter constraints will always conspire in the way we have shown to effect double linking, regardless of the amount of feature insertion or nonparsing required. Thus, in tableau 8 for input (25b), Faith tolerates the insertion of another association line on the optimal candidate (d). The faithful candidate (b), on the other hand, fatally violates License.

In tableau 9 (for input (25c)) the establishment of a new association line is similarly required for candidate (d). In this case the faithful candidate (c) incurs a fatal violation of NasVoi.

In tableau 10 (for input (25d)) we see a happy meeting of the needs of all of our constraints at once: in addition to fulfilling both License and NasVoi, the optimal form

Tableau 8

Input:  ‘dragonfly’

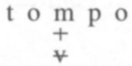
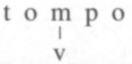
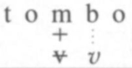
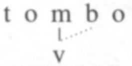
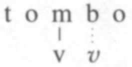
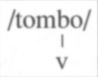
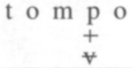
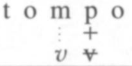
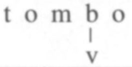
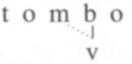
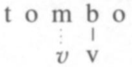
	Candidate	LICENSE	NASVOI	FAITH
a.			*!	*
b.		*!		
c.			*!	**
d. ☞				*
e.		*!		*

Tableau 9

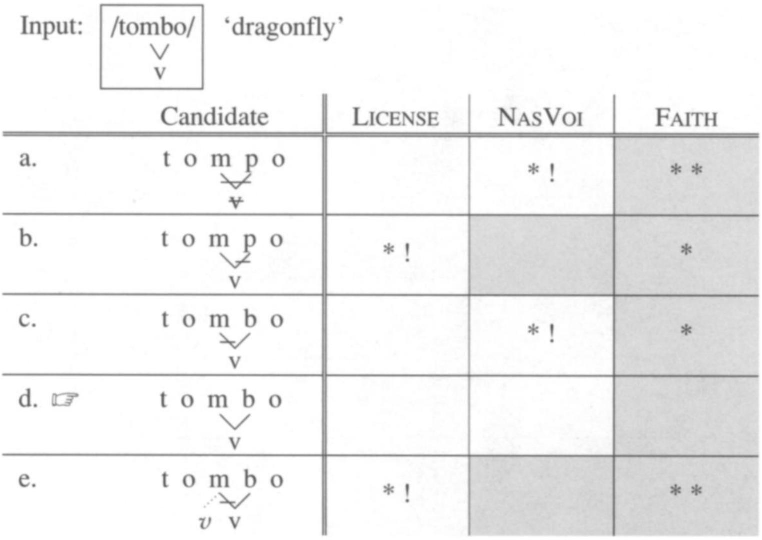
Input:  ‘dragonfly’

	Candidate	LICENSE	NASVOI	FAITH
a.			*!	*
b.		*!		**
c.			*!	
d. ☞				*
e.		*!		*

(d) is devoutly faithful to the input, a fact that will become significant in our discussion of lexicon optimization.

The last input to consider, (25e), starts off with separate [voice] specifications on the members of the NC cluster; again, the optimal form, candidate (d) of tableau 11, shows double linking instead, at a cost to FAITH.

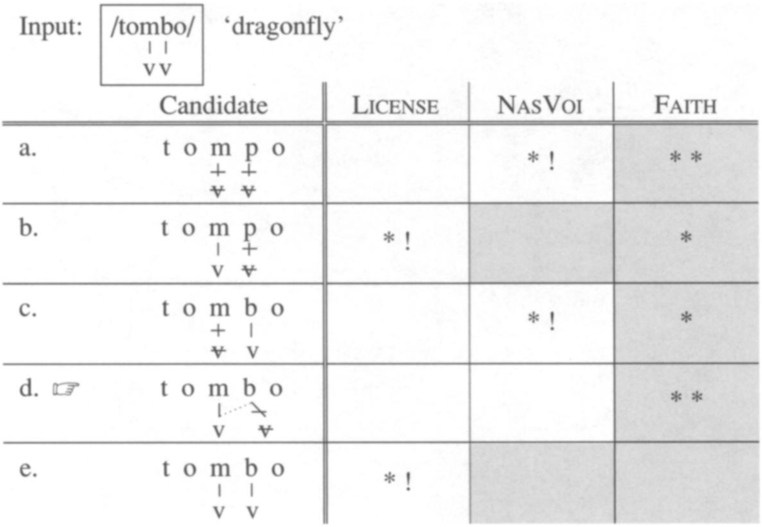
Tableau 10



Input: /tombo/ 'dragonfly'

	Candidate	LICENSE	NASVOI	FAITH
a.	tompo		*!	**
b.	tompo	*!		*
c.	tombo		*!	*
d. ☞	tombo			
e.	tombo	*!		**

Tableau 11



Input: /tombo/ 'dragonfly'

	Candidate	LICENSE	NASVOI	FAITH
a.	tompo		*!	**
b.	tompo	*!		*
c.	tombo		*!	*
d. ☞	tombo			**
e.	tombo	*!		

This experiment with various possible inputs bears out our earlier claim that there is no need for a separate theory of underlying feature minimization: the constraint hierarchy itself forces the correct output, irrespective of specification in the input. This means that there is no *grammatical* imperative against even a redundantly specified input form as in tableau 6 or tableau 10.

However, there may well be *learnability* factors restricting the choice of the underlying form, requiring that the proper underlying representation be inferable, as the "simplest" choice, from the constraint hierarchy. Language learners have at their disposal the strategy of Lexicon Optimization ("Stampean occultation"; see PS 1993:192, 196 for a full statement).

(26) *Lexicon Optimization*

Of several potential inputs whose outputs all converge on the same phonetic form, choose as the real input the one whose output is the most harmonic.

In order to develop these somewhat abstract considerations into a concrete analytical method, we propose the "tableau des tableaux" technique in tableau 12. Taking up a remark made by PS (1993:192), we compare each of the winning outputs seen above for harmonic status, each in relation to the corresponding input. The tableau des tableaux 12 assembles the input-output pairings established in tableaux 7–11, with the set of violation marks for each constraint. All of the winning outputs are doubly linked for [voice], satisfying both LICENSE and NASVOI; they differ only in violations of low-ranked FAITH. As shown, the "superhand" chooses (d) as the optimal input (i.e., the input associated with the most harmonic of the different outputs).

With Lexicon Optimization and tableau des tableaux as a guideline, the learner chooses the input form that maps onto an output in the way least offensive to the grammar of ranked constraints. For our purposes, this means that the learner will choose the input leading to the fewest faithfulness violations, to wit, the input bearing double linking of redundant [voice]. This conclusion, if correct, points up even more dramatically our basic conclusion: there is no requirement of underlying feature minimization.

Tableau 12

Tableau des tableaux: Evaluating outputs of the different inputs

	Input	Output	LICENSE	NASVOI	FAITH
a.	/tompo/	☞ t o m b o *v*			* ! *
b.	/tompo/ | v	☞ t o m b o | v			* !
c.	/tombo/ | v	☞ t o m b o | v			* !
d. ☞	/tombo/ \/ v	☞ t o m b o \/ v			
e.	/tombo/ | | v v	☞ t o m b o | v ~~v~~			* ! *

To recapitulate this section and the overall analysis, we rely on three broad categories of constraints: redundancy conditions, derivative licensing restrictions, and constraints against input/output disparities. Each of these is largely akin to notions widely held in modern phonology. Our approach to underspecification is novel in two important respects, however. First, our interpretation of licensing puts no penalty on feature cooccurrence per se; rather, a feature is merely required to be licensed in *some* fashion. Second, we rely crucially on the ranking and violability of constraints, notions that form the backbone of OT.

Continuing in this last vein, it may seem odd, even in the context of OT, to propose simultaneous constraints, one *demanding* that nasals be voiced (NasVoi) and the other *blocking* licensing of [voice] by nasal segments (License). Yet as noted at the outset of this section, these are just familiar notions in a new guise, and they must be regarded as two sides of the same coin: the import of NasVoi is that voicing is in a sense *inherent* in nasals (Stevens, Keyser, and Kawasaki 1986); yet it is surely the very redundancy of such voicing that also entails its phonological inertness. Whereas the antagonism between these two constraints has led past theories to assign them to complementary "levels" of the grammar (i.e., underspecification early and presence of redundant values late), we find a new possibility within OT: redundant specification is not irrelevant until "late" in the derivation, but rather is crucially a constant demand. The facts of Japanese provide striking support for this view. Our analysis therefore constitutes an argument in favor of the enforcement of phonological constraints *in parallel,* a notion central to OT.

5 Sonorant Voicing and Multiple Linking Conditions

5.1 The Problem

A small step back from Yamato NC clusters reveals some highly relevant questions lurking nearby. Our analysis has so far not addressed an important limitation of the process: it is only nasal sonorants that trigger voicing on following obstruents (/yom + te/ → *yonde* 'reading' (**yonte*), but /mi + te/ → *mite* 'seeing' (**mide*)). In singling out nasals from all sonorants as voicing triggers, Yamato Japanese is following a pattern paralleled in other languages, including Zoque (Penutian; Wonderly 1951/52), Mwera (Bantu; Harries 1950, Kenstowicz and Kisseberth 1977), among others. Although comforting, such cross-linguistic support is not enough to answer certain questions of a more fundamental nature:

Nonuniversality of NC voicing. Why don't we find postnasal voicing in all languages, including English (*impossible, *imbossible*)? Even within Japanese, NC voicing is restricted to the native (Yamato) stratum (as witnessed by well-known non-Yamato examples like *tempura* or *shinkansen*).

Nasals as privileged voicing triggers. If voicing spread takes place in order to allow for the presence of redundant voicing (by finding a licenser), why should this be restricted

Tableau 13

Input: /aki/ ‘autumn’

	Candidate	License	SonVoi	Faith
a. ! ! intended winner:	a k i		*!*	
b.	a k i v v	*!*		**
c.	a g i v		*!*	*
d.	a g i v		*!	**
e. ☞ wrong winner:	a g i v			***

to nasals? Why don’t nonnasal sonorants—say, vowels—spread their redundant [voice] in a parallel way?

To illustrate the second question, we consider the consequences of replacing the redundancy condition NasVoi in our current analysis by the more general SonVoi (27) requiring all sonorants, not just nasals, to be voiced.

(27) *SonVoi*
[sonorant] ⊃ [voice]

SonVoi expresses a general truth about segment structure and is operative within the constraint system of all languages, including Japanese. For an input like /aki/ (for *aki* ‘autumn’), replacing NasVoi by SonVoi in the analysis results in the incorrect multiply linked output **agi,* shown in (e) of tableau 13. More generally, *all* sonorants are wrongly predicted to cause voicing in neighboring obstruents. As we will show, the two questions posed above (restriction to nasals and nonuniversality) are closely related; both will require appeal to constraints on the multiple linking of features.

5.2 A Nonviable Approach: SonVoi Decomposition

One potential solution, attractive at first sight but ultimately not workable, relies on the decomposition of SonVoi into a universally ranked family of sonorant voicing conditions, as in (28) (see Itô, Mester, and Padgett 1993 for a detailed exposition of this kind of approach).

(28) *Sonorant voicing conditions and conjectured ranking*
NasVoi
[+nasal] ⊃ [voice]
ApproxVoi
[+approximant] ⊃ [voice]
VocVoi
[−consonantal] ⊃ [voice]
NasVoi ≫ ApproxVoi ≫ VocVoi

The notion of a family of constraints with intrinsic ranking is one of the central analytical tools of OT. The individual members of a family of constraints stand in particular dominance relations with respect to each other (given universally), but need not all be adjacent in the constraint ranking of a particular language (see PS 1993 on syllable sonority). The possibility that other constraints—most importantly, members of the Faithfulness family—might intervene at certain junctures in the overall hierarchy constitutes an important area of variation between phonologies.

For the case at hand, the most direct attack on the problem of distinguishing nasal voicing from other sonorant voicing is to rank Faith strategically between NasVoi and ApproxVoi/VocVoi, as in (29).

(29) NasVoi ≫ **Faith** ≫ ApproxVoi ≫ VocVoi

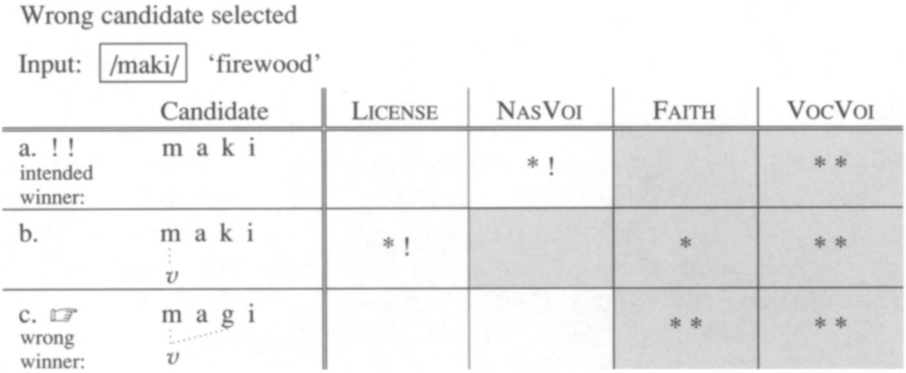
The occurrence of postnasal voicing follows from the dominance of NasVoi over Faith, the latter of which is hence violated in order to ensure compliance with the former. Other sonorant redundancy conditions are ranked below Faith and cannot command violations of it. This ranking yields the correct optimal output for *aki*, as shown in tableau 14. (For our discussion here and below, the distinction between ApproxVoi and VocVoi is not relevant, and we will simplify the presentation by restricting our attention to the latter.) Insertion of vocalic [voice], and the sharing of this feature with a licenser, as in (c) of

Tableau 14

Input: /aki/ 'autumn'

	Candidate	License	NasVoi	Faith	VocVoi
a. ☞	a k i				* *
b.	a k i v v	* ! *		* *	
c.	a g i v			* ! * *	

Tableau 15



Wrong candidate selected

Input: /maki/ 'firewood'

	Candidate	LICENSE	NASVOI	FAITH	VOCVOI
a. ! ! intended winner:	m a k i		* !		* *
b.	m a k i v	* !		*	* *
c. ☞ wrong winner:	m a g i v			* *	* *

tableau 14, are no longer possible; in spite of the condition demanding that vowels be voiced, the dominant position of FAITH entails that the optimal form is unspecified.[10]

Though the decomposition of SONVOI into these more particular conditions has no clear independent support within Japanese phonology, it is a natural step within OT that can be expected to be called for in other cases. More worrisome is the conjectured intrinsic ranking of this constraint family: with its implication that the voicing of a nasal is in itself of more consequence than the voicing of other sonorants (such as vowels), it lacks any obvious grounding in phonetic facts or markedness considerations.

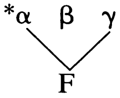
The most serious problem with the SONVOI decomposition analysis, however, is that it leads to unwanted insertion and linkage of [voice] in forms containing a nasal and a *nonadjacent* obstruent, such as *maki* 'firewood'. Nothing said so far distinguishes such NVC forms from NC forms like *tombo* 'dragonfly' analyzed in section 4, and tableau 15 illustrates how the SONVOI decomposition approach wrongly points to **magi,* with inserted [voice] spread to the medial obstruent, as the optimal output for underlying /maki/.

Looking beyond such individual examples, the analysis in tableau 15 predicts that nasals cannot cooccur with voiceless obstruents in the same form, a prediction patently wrong not only for Japanese, but in all likelihood universally as well. One source of the problem lies in the fact that the account does not recognize that postnasal voicing is restricted to strictly adjacent segments, a restriction that seems universal (we know of no cases that cross vowels). What guarantees this kind of locality? Following Kiparsky (1981), Levergood (1984), and Archangeli and Pulleyblank (1994), among others, we posit the constraint in (30) against "gapped" configurations (cf. also the *EMBED constraint in Smolensky 1993).

---

[10] For syllable structure reasons, other sonorant consonants besides nasals cannot precede obstruents in the output. When such clusters arise in input forms through morpheme concatenation, they are reparsed as geminates: /kaw + te/ → *katte* 'buying', /tor + te/ → *totte* 'taking', and so on, without any trace of voicing.

(30) *NoGap*



where β is a potential bearer of feature F

As the amended tableau 16 shows, the new constraint NoGap (undominated, and unranked with respect to License) rules out the previous winner (c), since a vowel is a potential bearer of [voice]—being a potential bearer is a matter of feature structure, not redundancy. Hence, the correct form (a) is selected instead. (In order to let the crucial rankings stand out in the tableaux, from here on we have omitted from the candidate rows the conventional dashed lines between the noncrucially ranked constraint columns.)

However, consideration of further candidates reveals that NoGap is not sufficient to solve the excessive voicing problem. Since vowels can bear [voice], there are candidates where spreading proceeds through the vowel, instead of skipping it. This leads straight to another way of wrongly deriving the medially voiced **magi* instead of *maki* shown in tableau 17. Here NoGap succeeds in disqualifying candidate (c), but it is powerless against the ungapped but still excessively voiced candidate (d), which wins over (a) because of NasVoi.

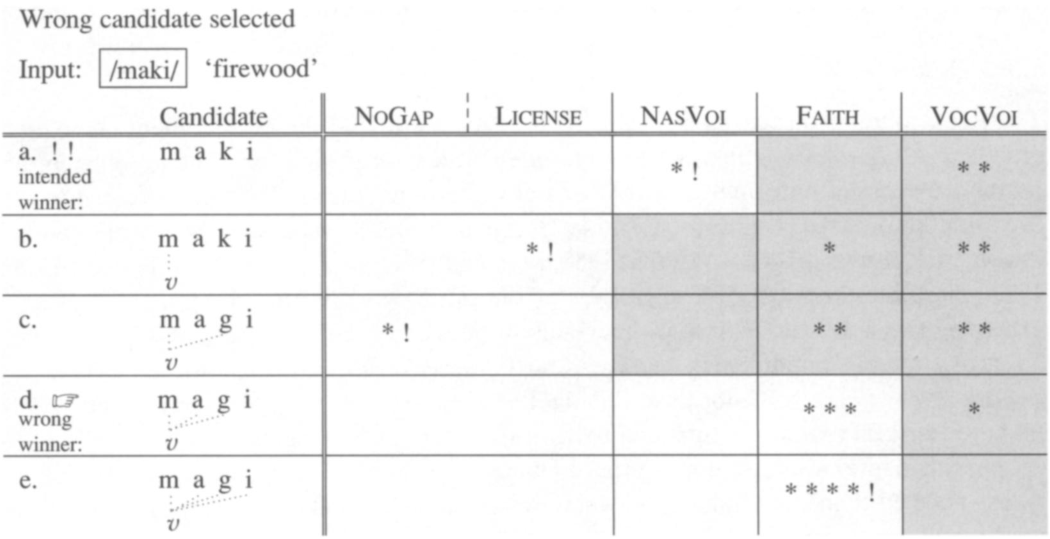
Besides leading to descriptively incorrect results, the SonVoi decomposition analysis entails erratic (under)specification patterns in surface forms whenever a voiced obstruent is present that can serve as a licensing anchor for [voice]. This is illustrated by forms with an *underlying* voiced obstruent such as *nabe* 'pot' (tableau 18). The voicing specification pattern in tableau 18 can only be described as arbitrary: the winning candidate shows voicing on vowels, but only when they lie on the path between a voice-craving nasal and a voiced obstruent (i.e., where necessary to fulfill both NasVoi and NoGap). Elsewhere (e.g., for the final vowel in *nabe*, candidate (b)), Faith prevents voicing on vowels. This last point raises a further disturbing question: since Faith is now crucially involved in making the final decision regarding the voicing specifications

Tableau 16

Input: /maki/ 'firewood'

	Candidate	NoGap	License	NasVoi	Faith	VocVoi
a. ☞	m a k i			*		* *
b.	m a k i v		* !		*	* *
c.	m a g i v	* !			* *	* *

Tableau 17



Wrong candidate selected

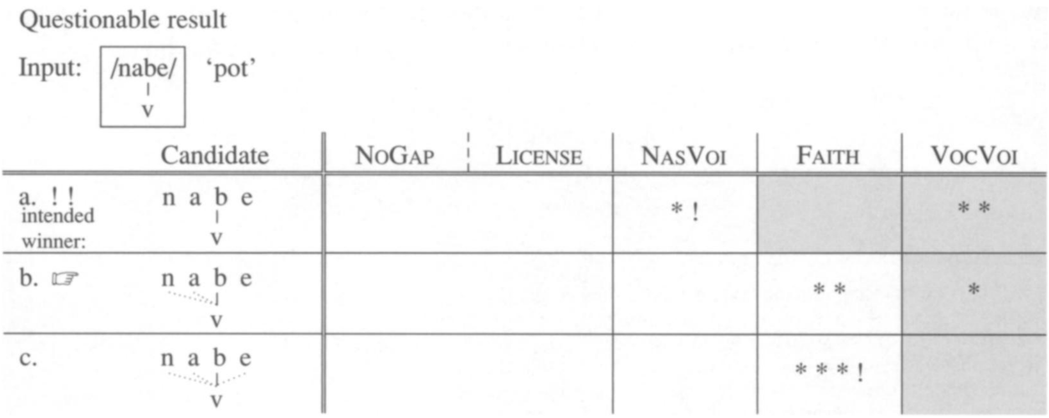
Input: /maki/ ‘firewood’

	Candidate	NoGap	License	NasVoi	Faith	VocVoi
a. ! ! intended winner:	m a k i			* !		* *
b.	m a k i *v*		* !		*	* *
c.	m a g i *v*	* !			* *	* *
d. ☞ wrong winner:	m a g i *v*				* * *	*
e.	m a g i *v*				* * * * !	

of vowels, the issue of different degrees of input specification (of redundant values) raises its head again, subverting the results of section 4.

The combined force of these considerations compels us to pursue an alternative approach that shifts the main emphasis in our analysis away from segment-focused voicing constraints toward syntagmatic linkage constraints. The basic idea behind the new approach is the following: NC sequences, in contrast to VC sequences, share voicing not because nasal *voicing* is somehow stronger than vocalic voicing, but because feature *linkage* is less marked in NC sequences than in VC sequences. We will show that this

Tableau 18



Questionable result

Input: /nabe/ ‘pot’
|
V

	Candidate	NoGap	License	NasVoi	Faith	VocVoi
a. ! ! intended winner:	n a b e | V			* !		* *
b. ☞	n a b e V				* *	*
c.	n a b e V				* * * !	

line of analysis enriches understanding of postnasal voicing, on the one hand, and connects with an interesting line of phonological research, on the other.

5.3 NC Linkage

The two problems discussed above—the locality issue, and the confinement of voicing effects to NC clusters—turn out to have one and the same solution. The key lies in the notion, to phrase it informally, that *like things interact*. This idea has been voiced in the literature before (see, e.g., Hutcheson 1973, Kiparsky 1988), most clearly in work centering on OCP effects (McCarthy 1986, 1988, Mester 1986, Selkirk 1988, 1993, Padgett 1991, 1992, Pierrehumbert 1993). The upshot of the latter work is that dissimilatory effects involving place of articulation are more likely between segments that are alike in other features, notably minor place features and features of stricture or sonority. Work by Selkirk (1988, 1993), Ní Chiosáin and Padgett (1993), McCarthy (1993), and Padgett (1994) finds promise in extending this idea to various assimilatory effects as well.

In this context, let us suppose that linkage of [voice] between nasals and obstruents is less marked than such linkage between liquids/glides/vowels and obstruents, because nasals and obstruents are already more similar in stricture and hence more prone to interact.[11] We implement this idea by means of the NoLink family of constraints in (31)—with the added caveat that the individual constraints should be taken not as irreducible principles, but as reflections of a deeper generalization (see the works cited above; the letters *V, G, L, N, C* in (31) denote vowels, glides, liquids, nasals, and obstruents, respectively).

(31) *Constraint family: NoLink*
No-VC-Link ≫ No-GC-Link ≫ No-LC-Link ≫ No-NC-Link

As conjectured concerning the family of SonVoi constraints discussed earlier (see (28)), this family is ranked intrinsically and universally; this ranking entails the generalization that interaction is less marked between segments more similar in stricture/sonority. Given this decomposition of NoLink, and the possibility that other constraints intervene between any pair of subconstraints, we propose the following scenario for Japanese:

(32) *Intervention of SonVoi*
NoLink family
. . . ≫ No-LC-Link ≫ **SonVoi** ≫ No-NC-Link ≫ . . .

---

[11] It is perhaps significant that only NC clusters share place features also. But the notion that "like things interact" cannot be interpreted to mean simply that segments already sharing feature linkage are more likely to share more—the similarity (e.g., in stricture or sonority) need not involve linkage (see Padgett 1991, 1992, Pierrehumbert 1993). The last point further indicates that the similarity idea cannot be fully geometrized, either by class node representations (Clements 1985; see Padgett 1994a for discussion) or by means of dependency-theoretic structures (Mester 1986, Selkirk 1988; see Itô and Mester 1994).

For our purposes, only the separation of No-NC-Link from the rest of the family is relevant. As in the discussion of SonVoi decomposition in section 5.2, we focus exclusively on the contrast between VC and NC. In these terms, the important subhierarchy of the constraint system of Yamato Japanese is the one in (33).

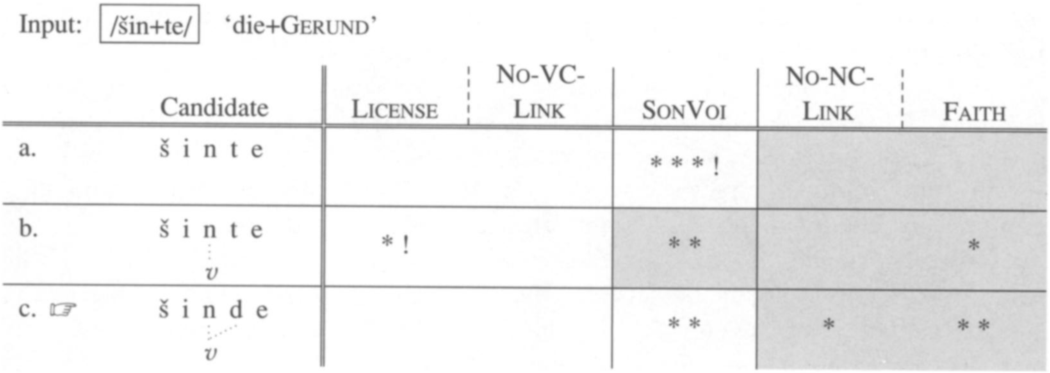
(33) No-VC-Link
|
SonVoi
|
No-NC-Link

This correctly entails postnasal voicing, on the one hand, and the failure of other postsonorant voicings, on the other. Combining (33) with the other constraints that play a role in the analysis (NoGap, License, and Faith), we end up with the partial ordering of constraints in (34). For present purposes, we are assuming that No-VC-Link is undominated, on a par with License and NoGap. (Within the overall grammar of Japanese, No-VC-Link is dominated by various constraints—enforcing palatalization and other vowel-consonant interaction effects—that are not relevant here; see Itô and Mester 1994, 1995, for discussion.)

(34) License No-VC-Link NoGap
SonVoi
Faith No-NC-Link

As an illustration of the analysis, consider first the input /šin + te/ 'dying' in tableau 19. Since this tableau involves only NC linkage, little has changed from before. The important point is that SonVoi is crucially ranked over No-NC-Link; were the opposite ranking correct, the input would surface unchanged as *_šinte_. Tableau 19 should be compared with tableau 20, where the input form /aki/ containing the VC sequence /ak/ is shown

Tableau 19



Input: /šin+te/ 'die+Gerund'

	Candidate	License	No-VC-Link	SonVoi	No-NC-Link	Faith
a.	š i n t e			* * * !		
b.	š i n t e v	* !		* *		*
c. ☞	š i n d e v			* *	*	* *

Tableau 20

Input: /aki/ 'autumn'

	Candidate	License	No-VC-Link	SonVoi	No-NC-Link	Faith
a. ☞	a k i			* *		
b.	a k i ⋮ *v*	* !		*		*
c.	a g i ⋮ *v*		* !	*		* *

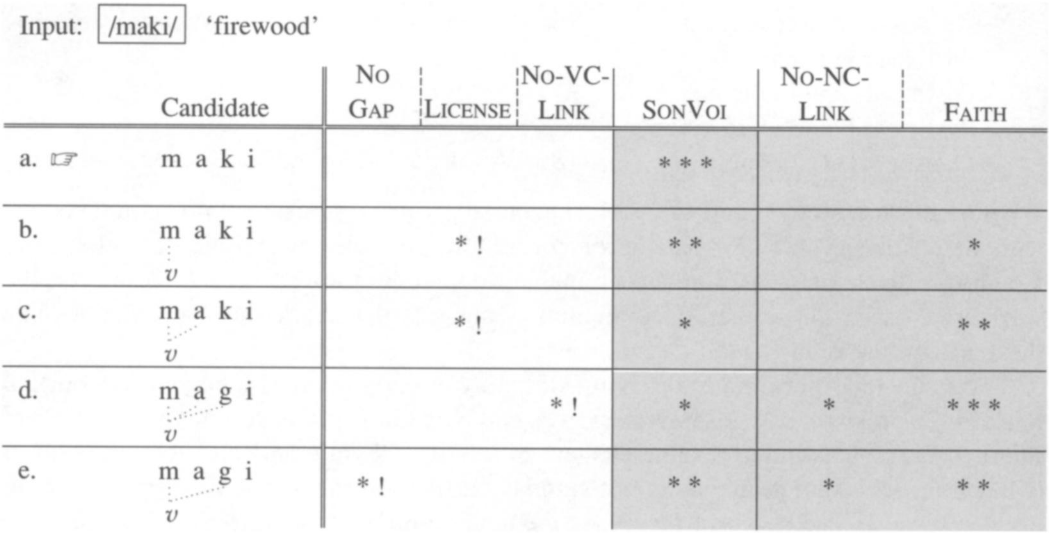
running the same constraint gauntlet. As usual, sonorant voicing may arise only if licensed by an obstruent link; hence the quick demise of candidate (b) of tableau 20. Candidate (c) of tableau 20 looks superficially similar to the winning candidate (c) of tableau 19. But linkage of a vowel to an obstruent is precisely what is prohibited by No-VC-Link; unlike No-NC-Link, this constraint ranks *above* SonVoi, and so postvocalic voicing is impossible, eliminating candidate (c) of tableau 20. In spite of its two SonVoi violations, the remaining candidate (a) of tableau 20 is the optimal form. We note for completeness that no evidence here motivates a ranking between Faith and No-NC-Link (we will shortly turn to a consideration of the role of Faithfulness in our analysis).

Recall from section 5.2 that the SonVoi decomposition analysis suffered from an excessive voicing problem in forms containing both a nasal and an obstruent, whether adjacent or not. We will now show that the NC linkage analysis is free of these problems and that it already contains the solution to the locality problem brought up earlier: the same prohibition on VC linkage that was operative in *aki* (tableau 20) also prevents long-distance postnasal voicing in *maki* 'firewood' (tableau 21). The previously problematic candidate (d), where voicing spread has swept through the vowel, now crucially violates No-VC-Link. The vowel-skipping candidate (e) continues to violate the constraint against gapped configurations posited in (30). As desired, the optimal candidate (a) mirrors the input in not containing any [voice] specification.

Our understanding of the opacity of intervening vowels echoes work stemming from Kiparsky (1981), in which opaque segments are viewed as *nontriggers* of the relevant process. In the present account, however, this behavior is not the result of process-specific stipulations on target and trigger, but rather follows directly from the ranking of quite general and independently motivated markedness conditions.

To sum up the discussion so far: Besides a universal SonVoi constraint, our analysis makes use of a universally ranked NoLink constraint hierarchy, whose existence is strongly supported by the empirical typology of dissimilation and assimilation patterns across languages. The only relevant "parameter" to be "set" within the phonology of

Tableau 21



Input: /maki/ ‘firewood’

	Candidate	No Gap	License	No-VC-Link	SonVoi	No-NC-Link	Faith
a. ☞	m a k i				* * *		
b.	m a k i v		* !		* *		*
c.	m a k i v		* !		*		* *
d.	m a g i v			* !	*	*	* * *
e.	m a g i v	* !			* *	*	* *

Yamato Japanese concerns the ranking of the voicing constraint with respect to the interaction constraint system. Here our analysis inserts SonVoi immediately above No-NC-Link within the NoLink hierarchy. This single move accounts simultaneously for three classes of facts: (a) the presence of postnasal voicing, (b) the absence of other postsonorant voicing, and (c) the strictly local character of postnasal voicing.

It is now a simple matter to answer the other question posed at the outset: why are there languages without postnasal voicing? The answer is that in such languages No-NC-Link joins other NoLink conditions in outranking SonVoi—hence, SonVoi cannot command the violation of No-NC-Link. We illustrate the two possibilities in table 1. More generally, and exploiting the entire hypothesized NoLink family, we predict the postsonorant markedness pattern in (35), derived by ranking SonVoi successively higher in the hierarchy.

Table 1

Ranking differences between No-NC-Link and SonVoi

Ranking	*Outcome*	*Examples*
SonVoi ≫ No-NC-Link	e.g., /. . . mp . . ./ ☞ [. . . mb . . .]	Yamato Japanese, Zoque
No-NC-Link ≫ SonVoi	e.g., /. . . mp . . ./ ☞ [. . . mp . . .]	Non-Yamato Japanese, English, etc.

(35) *Postsonorant voicing patterns*

No postsonorant voicing (SonVoi ranked below entire NoLink hierarchy)
Postnasal voicing
Postnasal-liquid voicing
Postnasal-liquid-glide voicing
Postsonorant voicing (SonVoi ranked above entire NoLink hierarchy)

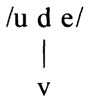
Whether this hierarchy is correct in all respects (e.g., in its exclusion of postliquid voicing without postnasal voicing—barring of course the possible interference of other constraints we are not considering here) remains a domain of future research. However, the work cited earlier on similarity in interaction suggests that markedness predictions like these are on the right track.

With the incorporation of the NoLink family in our grammar, it becomes important to clarify the relative roles of Faithfulness and NoLink in our account. Clearly, feature Faithfulness is an indispensable element of the overall grammar, NC voicing aside. It is Faithfulness that prohibits unmotivated departures from underlying form in general, preventing (e.g.) /aki/ from surfacing as **agi* by a spontaneous epenthesis of [voice] onto the obstruent. Closer to our concerns, it is the ranking of Faith below SonVoi that allows /šin+te/ 'dying' in Japanese to surface as *šinde*—if the ranking were reversed, we would have a grammar without NC voicing, and the outcome would be *šinte*. The low ranking of Faith in addition ensures that a monomorphemic Japanese form like *tombo* 'dragonfly' surfaces with NC voicing *irrespective of* the feature (under)specification in the input, an important result discussed at length in section 4. Turning then to NoLink, we saw in table 1 that the reranking of the interaction constraint No-NC-Link with respect to SonVoi also determines the occurrence of NC voicing. What then are the relative functions of faithfulness and the antilinking constraints?

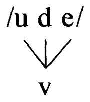
Unlike Faithfulness constraints, whose domain is the input-output relation, the NoLink constraints deal with output well-formedness questions in feature structure—hence their indifference to the *provenance* of feature linkage (underlying or inserted). This difference is less obvious than other traits of NoLink we have focused on—for example, its role in barring postvocalic voicing or nonlocal postnasal voicing, effects that Faith alone does not speak to in any case.

The main result of our analysis for the relative ranking of Faithfulness with respect to No-VC-Link is the following: No-VC-Link $\gg$ SonVoi (a/d, tableau 21); SonVoi $\gg$ Faith (c/a, tableau 19). Hence, by transitivity, No-VC-Link $\gg$ Faith. This derived ranking is of significance for cases where NoLink and Faithfulness conflict. Continuing the lexicon optimization investigation of section 4, let us consider two candidate inputs for the form *ude* 'arm', one with sparse [voice] specifications (36a) and one with fully linked [voice] (36b).

(36) a.



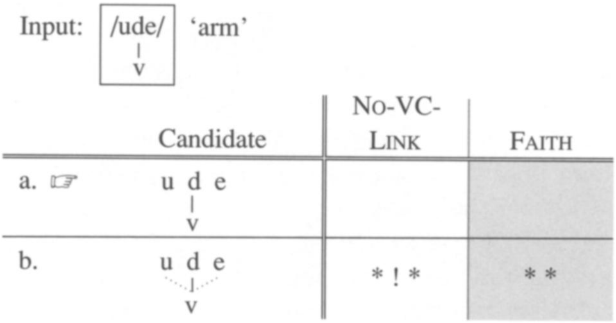
b.



For input (36a), No-VC-Link and Faith agree on an output with [voice] linked only to /d/, not to vowels. Yet this parallelism between Faith and NoLink vanishes with a shift in underlying form to the fully linked representation in (36b). Here the two constraints are in inevitable conflict: whereas No-VC-Link militates against any such links, whether inherited from the input or acquired through Gen, Faith insists on the preservation of underlying structure. As it happens, direct empirical evidence from (e.g.) Rendaku cannot bear on the correct surface form in this case.

Our analysis resolves this issue in favor of the underspecified output structure. Given the ranking of No-VC-Link over Faith, the grammar will select the candidate showing better linkage behavior, irrespective of the amount of linkage specified in the input. As a result, the selected output has no [voice] specification on vowels. This is shown in tableau 22 for the sparsely specified input (36a), and in tableau 23 for the fully linked input (36b). Reinterpreting this convergence of parsed output structures as determining lexically optimal inputs, the tableau-des-tableaux scheme of section 4, applied to tableaux 22 and 23, settles matters in favor of (36a) as the real input, as shown in tableau 24.

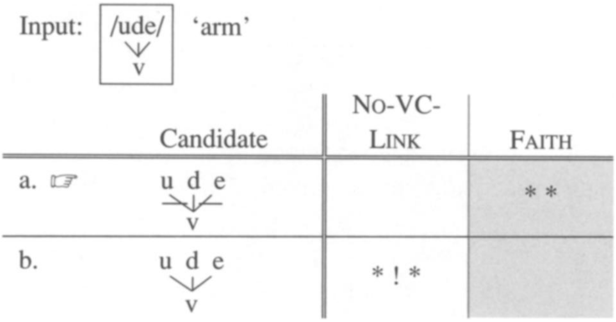
Tableau 22



Input: /ude/ V 'arm'

	Candidate	No-VC-Link	Faith
a. ☞	u d e V		
b.	u d e V	* ! *	* *

Tableau 23



Input: /ude/ V 'arm'

	Candidate	No-VC-Link	Faith
a. ☞	u d e V		* *
b.	u d e V	* ! *	

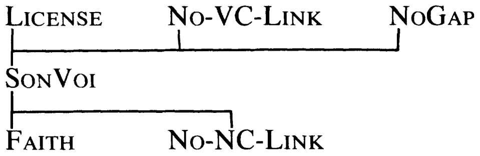
Tableau 24

	Input		Output	No-VC-Link	Faith
a. ☞	u d e | v	☞	u d e | v		
b.	u d e \\|/ v	☞	u d e \\|/ v		* ! *

6 Conclusion: Summary and Outlook

Recapitulating our main proposals in this article, we first turn to the three-level hierarchy of constraints repeated in (37).

(37) *Overall ranking of constraints*



In terms of the conflict-based ranking logic of OT, the constraint system in (37) has a straightforward set-up. Between a top layer consisting of the undominated (and in our analysis unviolated) constraints License, No-VC-Link, and NoGap and a bottom layer consisting of the dominated (and frequently violated) constraints Faith and No-NC-Link, we find the segment markedness constraint SonVoi. This simple ranking scenario is responsible for the intricate specification/underspecification behavior of voicing in Japanese: besides solving the voicing paradox, it accounts for the appearance of NC voicing, for the locality of the interaction, and for the absence of other postsonorant voicing in Japanese. And at the level of typology, the freedom of individual grammars to rerank SonVoi with respect to the substantively fixed hierarchy of NoLink constraints imposes plausible limits on the cross-linguistic variation space for voicing interactions.

Compared to earlier work, the analysis presented here constitutes a significant step toward a principle-based theory, eliminating rule stipulations. The six constraints in (37) are all independently motivated and arguably universal—if not in the exact formulation proposed here, then at least in spirit. As substantive elements of phonological theory, they are particular members of the constraint families shown in table 2 governing input/output relations, enforcing domain connectedness (together with other contiguity effects), regulating feature licensing, and controlling the markedness of segments and segmental links.

Taken as a whole, the analysis provides strong support for the basic tenets of OT, as developed by PS (1993): grammatical constraints are ranked and violable, and there

Table 2
Substantive typology of constraints

Constraint families				
	Intrinsically ranked			
Input/output disparity ("Faith")	*Segment markedness*	*Linkage markedness*	*Licensing*	*Domain connectedness*
ParseFeat	SonVoi	No-VC-Link	License(Voi)	NoGap
FillFeat		No-NC-Link		
ParseLink				
FillLink				

is no serial derivation. One could envision an account of Japanese in a serial phonology invoking constraint violation and repair. For example, we might say that the redundancy rule [nasal] → [voice], applying early, targets all nasals, violating a constraint against redundant feature specification. These violations could then be repaired, where possible: spreading to a neighboring obstruent grants licensing; otherwise, [voice] must delink again. As PS (1993) point out, such repair-and-rescue scenarios have the "Do α, except when β—unless γ" quality signaling a hidden appeal to ranking and violability, the very factors that are elevated to the level of principle in OT. In other words, such analyses would merely replicate the optimality-theoretic account in a stipulative and inexplicit way.

As far as conventional underspecification theory is concerned, it is replaced in our proposal by a theory of feature licensing that builds on earlier work on licensing (e.g., Itô 1986, Goldsmith 1990, Lombardi 1991, Itô and Mester 1993) and marking conditions (Kiparsky 1985, Padgett 1991:56–58) (see also Steriade 1995 for an independently developed concept of "indirect licensing"). Redundant feature specification is governed by a family of licensing constraints—License(Φ)—and not by the more familiar marking/feature cooccurrence conditions. Our work thus militates against the use of feature cooccurrence restrictions like *[+sonorant, +voice] to ensure underspecification, since they imply a simple incompatibility between the relevant features. As we have shown, there is no such incompatibility; rather, there is only a failure of licensing. Only this notion of licensing can illuminate the free occurrence of redundant features in doubly linked structures. We are of course not arguing against feature cooccurrence restrictions in general, which are needed to rule out cooccurrences of *antagonistic* features, such as *[+sonorant, −voice] (or, in a theory with privative [voice], *[+sonorant, +spread glottis]; see Mester and Itô 1989, Lombardi 1991). Antagonistic feature cooccurrence restrictions are independent of Licensing Theory (e.g., there is no sense in which double linking renders voicelessness in sonorants well formed) and play an important role in constraining the derivation of segments by assimilation; see Kiparsky 1985, Pulleyblank 1989, Cohn 1989, Archangeli and Pulleyblank 1994, Padgett 1991:48–63, 1994b.

In another vein, we note the possible implications of our results for a broader conception of underspecification. The program developed here for redundant features might be profitably extended to include an investigation of the specificational behavior of *unmarked* (but not redundant) values of contrastive features, thereby addressing the perennial topic of degree of underspecification—full, contrastive, or radical. Thus, we anticipate that the opposing contrastive and radical viewpoints may reveal themselves as reifications of two different orderings of antagonistic constraints. As an example, consider the place feature [coronal], perhaps the best-investigated case in point (see Paradis and Prunet 1991 and references therein). We might attribute [coronal] behavior to a conflict between some kind of licensing constraint, on the one hand (see *PL/COR in PS 1993:181, Kiparsky 1994), and constraints against empty Place nodes and unparsed features, on the other hand (FILLPLACE, PARSEFEATURE; ibid.). If such an approach proves fruitful, the contrast between "radical" and "contrastive" views of underspecification reduces to a contrast in ranking, with empirical consequences to be pursued. In a similar vein, redundant feature specification is determined in our view by a conflict between licensing constraints militating against the presence of redundant features and constraints requiring the presence of those very same features. The ranking of these (families of) constraints with respect to each other tips the scales in favor either of specification, or of underspecification.

Finally, let us return one last time to the issue of redundant feature underspecification in outputs. Future investigations will have to devote serious thought to proposals (as in Steriade 1995) that allow the phonology direct access to a vast range of phonetic properties, and in this way are able to make use of a multitude of distinctions in phonological descriptions that are not available within the limited feature set of Jakobsonian phonology. There is no doubt that careful attention must be paid to the phonetic interpretation of phonological representations. However, it seems to us that a direct importation of acoustic, physiological, and aerodynamic factors into phonology, although making certain generalizations more easily statable (like any expansion of the descriptive vocabulary), might lead to a loss of explanation.[12] Proposals reviving the idea of "phonological projections" (Halle and Vergnaud 1978) in the form of rule-specific visibility parameterization have little trouble in making fully specified phonological representations compati-

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[12] For example, it has been proposed that voiced obstruents can be distinguished from voiced sonorants by referring to the aerodynamic fact that the production of the former, but not the latter, regularly goes hand in hand with an expansion of the pharynx (see Steriade 1995, and the development in Pater 1994). But, as John Kingston (personal communication) reminds us, this does not take into account that the production of voicing on the obstruent portion of intervocalic NC clusters—that is, precisely the clusters under discussion in this article—involves little expansion of the pharynx, if any (since the oral stop portion is of extremely short duration). If so, a reference to "expanded pharynx" in this context amounts to a phonological diacritic for obstruent voicing.

ble with the facts by declaring, for certain processes, that only marked, or only contrastive, features may be accessed (Calabrese 1994)—a descriptive success bought at the price of rule-by-rule stipulations, which block the search for more fundamental phonological principles.[13]

Although the particular facts discussed throughout this article are specific to Japanese, our approach to redundant feature (under)specification is based on a general theory of feature markedness and licensing that applies to a broad class of other cases. Facts like those of NC voicing have not generally informed the discussion of underspecification in the literature. This results partly from the difficulty in identifying such facts, and not from their rarity (for features other than voicing, see the brief analysis of Turkish rounding effects presented in Itô, Mester, and Padgett 1993:18–28 and the more fully developed treatment in Ní Chiosáin and Padgett 1993). We have chosen Yamato Japanese as a testing ground for our licensing-based theory of feature specification, with its entailment of underspecification as an emergent output property, because it is particularly suited for the empirical investigation of phonological voicing: the morphophonemic process of Rendaku allows access to information about phonological specification and underspecification that is not usually available in other languages.

Like all observations, those about Japanese voicing specifications are ultimately theory bound—here they are molded by the autosegmental/OCP-based view of Rendaku, Lyman's Law, and Voicing Spread in Itô and Mester 1986, itself predicated on the fundamental assumption that phonological representations are redundancy free. Within optimality-theoretic approaches championing full specification (see, e.g., Smolensky 1993 for a step in this direction), the project of capturing the central phonological properties of Japanese voicing strictly in markedness terms has remained so far elusive, but is clearly worth pursuing—we await competitive alternatives that are able to match the underspecification-based account in terms of elegance and depth of explanation.

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[13] Consider, for example, the set of grammars that would result from the free permutation of visibility clearances among the phonological rules posited in Calabrese's (1994) restatement of Itô, Mester, and Padgett's (1993) optimality-theoretic analysis of voicing in Japanese.

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