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# 3 The Phonological Lexicon*

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## 0 Introduction: Stratification and Lexical Subsetting

This chapter presents some recent results on a central aspect of Japanese phonology, namely, the structure of the phonological lexicon. The issue here is the fundamental division of the lexicon into different strata: native (or Yamato), Sino-Japanese, and Western loans at various stages of assimilation. An understanding of such stratification patterns not only is a prerequisite for serious analytical work in Japanese phonology (and elsewhere), but enables us to raise the question of what, if anything, the existence of lexical strata might tell us about the organization of the phonology (and ultimately, the grammar) as a whole. Within Optimality Theory (Prince and Smolensky 1993), as we will see, this issue is intimately connected to the form and function of faithfulness constraints.

In virtually all languages whose grammars have been explored to any degree of detail, the lexicon shows evidence for some internal stratification. Such different lexical strata are usually referred to with terms like "native vocabulary," "assimilated loans," "foreign vocabulary," or by labels identifying the loan source: "Arabic," "Latinate," "Sanskrit," "Spanish," "Sino-Korean," "Swahili," "Portuguese," etc. While the ultimate origin of a given lexical item consists of etymological information without any relevance for the synchronic grammar, such classifications often have synchronic impact in that they reflect, more or less accurately, an overall partitioning of the total set of lexical items into distinct subsets whose members behave alike with respect to several different criteria within the grammar, including observance of morpheme structure constraints, morpheme combinatorics, and morphophonemic alternations.

For Japanese, there is a well-established tradition[1] of distinguishing between *yamato-kotoba* "native (Yamato) vocabulary" (1a), *kan-go* "Sino-Japanese vocabulary" (1b), *gairai-go* "foreign vocabulary" (1c), and *gisei-/gitai-go* "onomatopoetic/mimetic vocabulary" (1d).[2]

(1) Examples of vocabulary items from:

a. *Native (Yamato) stratum:*

| | |
|---|---|
| kotoba | "word, language" |
| oto | "sound" |
| hanaši | "talk" |
| kuruma | "wheel, car" |

b. *Sino-Japanese stratum:*

| | | |
|---|---|---|
| geŋ-go-gaku | "linguistics" | (speak-word-study) |
| oN-in-roN | "phonology" | (sound-rhyme-theory) |
| deN-wa | "telephone" | (electric-speak) |
| ǰi-dō-ša | "automobile" | (self-moving-vehicle) |

c. *Foreign stratum:*

| | |
|---|---|
| raŋgēji-raboratorī | "language laboratory" |
| saN-tora | "sound track"[3] |
| terefoN-kādo | "telephone card" |
| pato-kā | "patrol car, police car"[4] |

d. *Onomatopoetic/Mimetic stratum:*

| | |
|---|---|
| pera-pera | "(speak) fluently" |
| kori-kori | "crisply" |
| sui-sui | "lightly and quietly" |
| mota-mota | "slowly, inefficiently" |

This stratification corresponds in kind to the distinction in English between the Germanic versus the Latinate vocabulary, but is more accessible and conscious to the nonspecialists because of its reflection in the writing system.[5] It is also more elaborate in that four different morpheme classes need to be recognized. *Yamato-kotoba* forms the native stratum (1a), corresponding to the Germanic/Anglo-Saxon vocabulary in English. Analogous to the Latinate/Greek stratum in English, *kan-go* (1b) constitutes the vast technical and learned vocabulary of the language, and appears mostly as compounds consisting of bound roots. Taking over the role of Sino-Japanese as the main source of new technical vocabulary are the *gairai-go*, the ever-increasing loanwords of the foreign stratum (1c). The examples in (1a–c) were chosen to illustrate cases in which items from different morpheme classes share some core meaning.

Alongside these three strata (Yamato, Sino-Japanese, and foreign), there is the substantial class of *gisei-go* and *gitai-go* (1d), mimetic or sound-symbolic vocabulary items that play a much more important role in the overall system than corresponding words in English.[6] As J. D. McCawley (1968b: 64) points out, mimetics "function syntactically as manner adverbs and may refer to just any aspect (visual, emotional, etc.) of the activity involved, rather than just its sound."

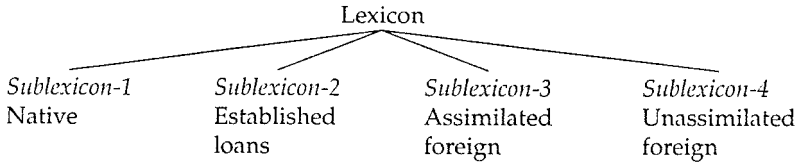
If such morpheme classifications were nothing more than a record of etymological history, they would be of little linguistic interest.[7] However, as is familiar from the classical linguistic literature on the subject, they require explicit

synchronic recognition if, and as far as, they continue to play a role in the grammar.[8] As has been shown in numerous cases, morpheme classes demarcate the areas of the lexicon where certain phonological regularities hold (segmental alternations and structural constraints), and they serve to restrict morpheme combinatorics.[9] Occasional hybrid formations aside, Latinate suffixes tend to attach to Latinate stems, Sino-Japanese roots compound only with other Sino-Japanese roots, etc.

While the factual existence of stratification can hardly be in doubt, its appropriate place in the theory has remained unclear. After some early influential work in Praguean phonology,[10] there have only been very few studies focusing on the question of what the existence of lexical strata might mean for the theory of the lexicon and for the organization of the grammar.[11] The topic emerged on a larger scale in early generative phonology, where the serious analysis of the morphophonemics of English and other languages required a systematic way of referring to lexical strata (Chomsky and Halle 1968 and related work).

An initial idea might be that stratification can be depicted as in (2), where the lexicon is partitioned into parallel sublexica containing native items, loan items, etc.

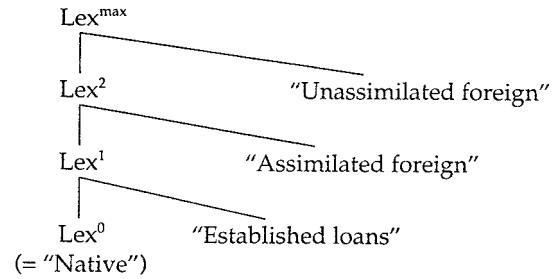
(2)




However, a significant finding of Kiparsky (1968), taken up and extended in Saciuk (1969), is that a model like (2) misses two central and interrelated features of lexical structure – the *gradual* and *hierarchical* character of lexical stratification. Lexical items do not come neatly packaged into groups labeled [±foreign]; rather, different degrees of nativization among foreign words are commonplace.[12] Instead of a partitioning into parallel and disjoint [+foreign] and [–foreign] sublexica, we have "a hierarchy of foreignness, with exceptions to one rule always being exceptions to another rule, but not vice versa" (Kiparsky 1968: 20).

On the basis of a detailed investigation of the phonological lexicon of contemporary Japanese, Itô and Mester (1995a, 1995b) take up this idea and argue for a model of the phonological lexicon in which this kind of hierarchy among lexical items plays a central role. In this conception, which is to be further developed and motivated below, the central notion is that of a "lexical constraint domain;" that is, analyzing lexical stratification means analyzing the inclusion and overlap relations between constraint domains. The main result is that lexical items are organized in terms of an overall *core–periphery structure* that can be depicted as in (3).[13]

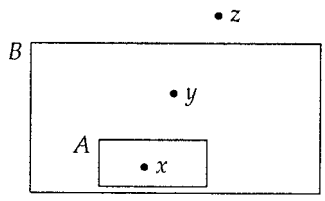
(3)




In this model, the relevant structural organization of the lexicon is set inclusion, leading from the innermost lexical core $Lex^0$ to the most inclusive set $Lex^{max}$ comprising all lexical items. In this set inclusion hierarchy $Lex^0 \subset Lex^1 \subset Lex^2 \subset \ldots \subset Lex^{max}$, $Lex^0$ corresponds to what is usually called the "native stratum," $Lex^1$ includes "native" and "established loans," and so on. Crucially different from the sublexicon model in (2), the (higher) lexical strata do not directly correspond to $Lex^1$, $Lex^2$, etc., but are defined by set complementation, following the general schema $Lex^i - Lex^{i-1}$ (i.e. $Lex^i$ minus $Lex^{i-1}$). Thus the stratum of established loans in (3) is the set $Lex^1 - Lex^0$, etc. More inclusive sets can be read off the diagram in an analogous way: the set of all non-native items is $Lex^{max} - Lex^0$, the complement of $Lex^0$, etc. The elements of $Lex^0$ fulfill lexical constraints in the maximal way and form the core of the lexicon. Moving outwards from the core, we encounter items that violate more and more constraints until we encounter, at the periphery, items fulfilling only a small subset of the constraints. These constraints are truly fundamental in the sense that they define the basic syllable canons and other central aspects of the language.

Structures as in (3) are built out of a network of implicational relations involving lexical items and phonological constraints of the following kind: items that are subject to constraint *A* are also always subject to constraint *B*, but not all items subject to *B* are also subject to *A*. This makes *A* a constraint with a more restricted domain than *B* – in fact, *A*'s domain is properly included in *B*'s domain, as schematically shown in (4).

(4)




Here *x* is in the domain of *A* and of *B*, *y* is in the domain of *B*, but not of *A*, and *z* is in the domain of neither *A* nor *B*. It is not possible for an item to be in the domain of *A* without being in the domain of *B*. If lexical items and constraints

consistently pattern in this way, it makes sense to talk about core–periphery relations, with *x* being closer to the lexical core than *y*, *z* occupying the periphery, etc.

The rest of this chapter is organized as follows. After exploring the core–periphery relations of the various constraints whose interaction gives rise to some of the characteristics of the Japanese sound pattern (section 1), we turn to the formal analysis of the constraint domains in Optimality Theory (section 2), test the model's predictions and expand it further by exploring the development of stratified grammars (section 3), and conclude with a discussion of some further theoretical issues regarding stratification and faithfulness constraints (appendix).

# 1 Phonological Constraints: Canonical Patterns, Alternations, and Domains

We see clear instances of core–periphery relations when we consider how the different classes of lexical items discussed above (see (1)) behave with respect to the constraints in (5) (taken from Itô and Mester 1995a, 1995b) operative in the phonological lexicon of Japanese.

(5) a. SYLLSTRUC: Syllable structure constraints (see below)
b. NOVOICEDGEM (NO-DD): "No voiced obstruent geminates" (**bb*, **dd*, **gg*, etc.)
c. NOVOICELESSLAB (NO-P): "No singleton-*p*": a constraint against nongeminate [p]
d. NONAS⌒VOICELESS (NO-NT): "Post-nasal obstruents must be voiced" (**nt*, **mp*, **ŋk*)

The set of basic syllable constraints of Japanese collectively referred to as SYLLSTRUC includes, among others, *COMPLEX (disallowing complex onsets and complex codas) and CODACOND (limiting codas to place-linked consonants or segments without consonantal place (= nasal glide N)).[14] These constraints are responsible for the well-known verbal paradigm alternations (6), where the gerundive form shows gemination (6a) or epenthesis (6b) to avoid high-ranking CODACOND or *COMPLEX violations.

(6) a. tor-u "take-Present" tot-te "take-Gerundive" *tor-te
b. kas-u "lend-Present" kaši-te "lend-gerundive" *kas-te

The pattern is not limited to the verbal paradigm, but is productively found in verbal root compounds (7), where the unsyllabifiable input cluster *kt* is either split by epenthesis or geminated.

(7) fuk- "blow" tob- "fly"
fuki-tobu, fut-tobu "blow-away" *fuk-tobu

The constraint against voiced geminates (No-DD) also plays an active role in verbal root compounding. As shown in (8), the prefixal roots *ow-* and *tsuk-* induce gemination of the following consonant (*ok-kakeru*, *tsut-tatsu*). When this consonant is a voiced obstruent, the result is not a geminate (**od-dasu*, **tsud-dasu*) but rather a homorganic nasal + voiced obstruent sequence (*on-dasu*, *tsun-dasu*).

(8)

| | | | | | |
|---|---|---|---|---|---|
| ow- | "chase" | kake- | "run" | ok-kakeru | "run after"[15] |
| | | tsuk- | "arrive" | ot-tsuku | "overtake" |
| | | das- | "put out" | on-dasu, *od-dasu | "drive out" |
| tsuk- | "stab" | kom- | "be full" | tsuk-komu | "cram" |
| | | tat- | "stand" | tsut-tatsu | "stand straight" |
| | | nomer- | "lean" | tsun-nomeru | "lunge forward" |
| | | das- | "put out" | tsun-dasu, *tsud-dasu | "thrust out" |

As shown in (9), similar patterns are observed for intensive *-ri* adverbs with internal gemination.[16] The corresponding single consonants are found in the base forms, which occur as reduplicated adverbs (e.g. *zabu-zabu*), or as stems of other lexical formations (*hiso-ka* = adj., *nobi-ru* = verb, etc.).

| | | | | | |
|---|---|---|---|---|---|
| (9) a. | uka(-uka) | ukka(-ri) | | "absentmindedly" |
| | biku(-biku) | bikku(-ri) | | "surprising, frightening" |
| | šito(-šito) | šitto(-ri) | | "wet, rainy" |
| | hiso(-ka) | hisso(-ri) | | "secretly" |
| | gusa(-ri) | gussa(-ri) | | "plunging in (with a dagger)" |
| | hono(-ka) | honno(-ri) | | "dimly, faintly" |
| | šimi(-ǰimi) | šimmi(-ri) | | "deeply, heartily" |
| b. | zabu(-zabu) | zambu(-ri) | *zabbu(-ri) | "raining heavily" |
| | šobo(-šobo) | šombo(-ri) | *šobbo(-ri) | "lonely" |
| | koga(-su) | koŋga(-ri) | *kogga(-ri) | "toasted, roasted" |
| | nobi(-ru) | nombi(-ri) | *nobbi(-ri) | "leisurely" |
| | nodo(-ka) | nondo(-ri) | *noddo(-ri) | "tranquil, calm" |

The voiceless labial restriction (No-P) rules out any *p* that is exclusively linked to onset position (henceforth, "singleton-*p*").[17] An underlying singleton-*p* is debuccalized to [h] and appears allophonically as bilabial [ɸ] and palatal [ç] before high back and high front vowels, respectively. Following standard transcriptional practice, we render these as [fu] and [hi]. Besides the well-known variants *nippon* and *nihon* "Japan" and the adverb *yappari~yahari* "after all," we find numerous instances of the *p~h* alternation, some of which are listed in (10)–(12).[18]

(10) Verbal root compounding (cf. (8) above):

| | | | | | |
|---|---|---|---|---|---|
| hik- | "pull" | har- | "stretch" | hip-paru | "pull strongly" |
| ow- | "chase" | haǰime- | "start" | op-paǰimeru | "really start" |
| tsuk- | "stab" | hašir- | "run" | tsup-paširu | "dash, race" |

(11) *ma-* prefixation:

| | | | | |
|---|---|---|---|---|
| | hiruma | "daytime" | map-piruma | "broad daylight" |
| | hadaka | "naked" | map-padaka | "stark naked" |
| cf. | kuro | "black" | mak-kuro | "pitch black" |
| | naka | "center" | man-naka | "dead center" |

(12) Sino-Japanese compounding:[19]

| | | | |
|---|---|---|---|
| hatsu-bai | "sale" | šup-patsu | "departure" |
| hai-tatsu | "distribution" | šim-pai | "worry" |
| tai-fuu | "typhoon" | top-puu | "sudden wind" |

By adding a voicing feature, Rendaku gives rise to *h~b* alternations in Yamato word compounding.[20]

(13)

| | | | |
|---|---|---|---|
| hana | "flower" | ike-bana | "flower arrangement" |
| hata | "side, bank" | kawa-bata | "river bank" |
| fue | "flute" | kuči-bue | "mouth flute, whistle" |
| hito | "person" | tabi-bito | "traveller" |

Finally, the constraint against nasal⌒voiceless sequences (No-NT) (5d)[21] is responsible for a widespread and fully regular alternation in verbs involving the gerundive ending *-te* and the past tense ending *-ta* (14).[22]

(14)

| | *Base* | *Gerundive* | *Past* | |
|---|---|---|---|---|
| | šin- | šin-de | šin-da | "die" |
| | in-[23] | in-de | in-da | "leave" |
| | yom- | yon-de | yon-da | "read" |
| | susum- | susun-de | susun-da | "progress" |
| | hasam- | hasan-de | hasan-da | "put between" |
| cf. | mi- | mi-te | mi-ta | "see" |
| | hašir- | hašit-te | hašit-ta | "run" |
| | kaw- | kat-te | kat-ta | "buy" |

Verbal root compounding also shows ample evidence for a postnasal voicing alternation, as illustrated in (15), where the first verbal root *fum-* "to step on" ends in a nasal.

(15)

| | | | | |
|---|---|---|---|---|
| tsukeru | "attach" | fun-dzukeru | *fun-tsukeru | "trample on" |
| haru | "stretch" | fum-baru | *fum-paru | "resist" |
| kiru | "cut" | fuŋ-giru | *fuŋ-kiru | "give up" |
| šibaru | "tie" | fun-jibaru | *fun-šibaru | "immobilize" |

While the formal structure of these constraints and their phonetic grounding are an interesting topic deserving further exploration, the focus of this chapter is a different one, namely, their systematic patterning in the various lexical strata. Besides leading to a large number of morpheme alternations in Yamato and Sino-Japanese items (see (6)–(15)), the constraints in (5) leave their mark

on the phonological lexicon as a whole in a less direct, but equally significant way. They result in static restrictions on morpheme shape, independent of any alternations. The way in which these restrictions are distributed over the lexicon reveals the details of its stratal structure.

The syllable constraints of Japanese collectively referred to as SyllStruc in (5a) are observed in all lexical strata. An item such as *trot*, with a complex onset and non-place-linked consonantal place in the coda, is simply not a viable lexical item in Japanese. While No-dd (5b) is observed in most of the lexicon, violations are encountered in the unassimilated foreign vocabulary (e.g. *roddo* "rod" or *nobbu* "knob;" cf. the nativized variant *nobu*). No-p (5c) is frequently violated in all kinds of foreign items (e.g. *peepaa* "paper"), including cases showing effects of nativization (e.g. *sepaado* "German shepherd dog").[24] Finally, while No-nt (5d) is observed in the Yamato vocabulary, violations are freely found elsewhere in the lexicon, not only in the foreign stratum (e.g. *kompyuutaa* "computer," *santa* "Santa"), but also in Sino-Japanese items (e.g. *sampo* "walk," *hantai* "opposite").[25]

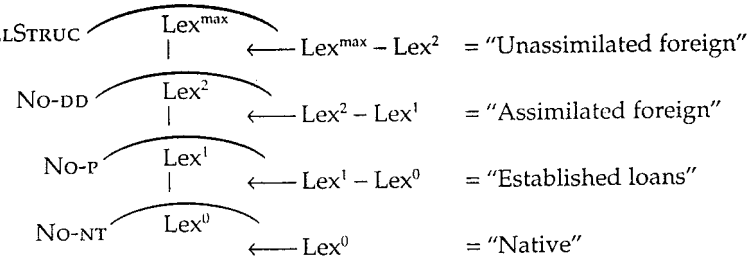
All of this may strike the casual observer as nothing but a collection of random facts and idiosyncracies; in reality, we are dealing with an instance of a simple generalization holding for every stratified lexicon. The table in (16) reveals the systematicity of the pattern, in the form of hierarchical inclusion relations between the domains in the phonological lexicon where the various constraints are active.

(16)

| | *SyllStruc* | *No-dd* | *No-p* | *No-nt* |
|---|---|---|---|---|
| Yamato | ✓ | ✓ | ✓ | ✓ |
| Sino-Japanese | ✓ | ✓ | ✓ | violated |
| Assimilated foreign | ✓ | ✓ | violated | violated |
| Unassimilated foreign | ✓ | violated | violated | violated |

The situation seen in (16) is an instance of the abstract pattern shown in (4). Everything subject to No-dd is also subject to SyllStruc, but not vice versa; everything subject to No-p is also subject to No-dd, but not vice versa, etc. Given the cross-linguistic frequency of such patterns, it is natural to hypothesize that some fundamental property of lexical constraint systems must be at work here. The nesting of constraint domains is depicted in (17), where in Japanese "Native" is instantiated by Yamato and "Established loans" by Sino-Japanese.

(17)



Several observations can be made about this kind of model. First, viewed as a large set of elements, the whole lexicon is organized as a structure with more and more inclusive subsets: a member of $Lex^i$ is also a member of $Lex^{i+1}$ in that it fulfills all the constraints of $Lex^{i+1}$.

Second, a consistent pattern of set inclusion of this kind entails the existence of an innermost domain included in all the larger domains – in other words, a core area governed by the maximum set of lexical constraints (and hence "unmarked").

Third, the fundamental structural characteristic of the lexicon is the set-inclusion structure, and not the existence of large, homogeneous, and well-defined strata, which is a secondary phenomenon. It is certainly true that some traditional vocabulary strata emerge as lexical areas that stand out in virtue of serving as the domains for a number of different constraints, somewhat reminiscent of the bundles of isoglosses defining dialect areas in a traditional dialect map. In Japanese, this holds true for Yamato and Sino-Japanese; such groupings constitute genuine morphological classes in the sense of Aronoff (1994), which can be referred to as such in the grammar.[26] On the other hand, a closer inspection (Itô and Mester 1995a: 198–205) also supports the cross-linguistic finding that the class of foreign items does not constitute a uniform stratum, but is best thought of as the cumulative totality of the items occupying less and less central areas of the lexicon.[27] In (17) and elsewhere in this chapter, this nonuniformity is acknowledged by the split into "unassimilated" and "assimilated" foreign items. In reality, many finer distinctions are hidden beneath this coarse classification: the less nativized an item is, the more it disobeys lexical constraints, i.e. the more it falls outside of various constraint domains and is located towards the periphery of the lexical space.

While we continue to use historicizing terms like "native," "loan," "foreign," etc., because they are firmly established in this area, it is very important to understand them in a synchronic-structural sense. Some items are historically speaking "native" in that they are not borrowed from any other language, but they are still peripheral in a synchronic-structural sense. Examples of non-borrowed peripheral items include exclamations like [če?][28] and certain contractions, such as the syncopated form *anta*[29] (from *anata* "you") with an *-nt-* cluster. On the other hand, there are also historically borrowed items with core behavior. A case in point is the Portuguese loan *karuta*, which is treated as a core item with respect to Rendaku voicing in *hana-garuta* "flower card game." Similar behavior is found with certain Sino-Japanese items, such as *keŋka* "quarrel" in *oyako-geŋka* "quarrel between parent and child," or *teŋka* "empire" in *onna-deŋka* "petticoat government."[30] The last examples, which exhibit a mixture of native characteristics (Rendaku) with non-native characteristics (*-ŋk* – clusters), also show that non-homogeneity is not restricted to the foreign stratum, but is also found in other areas of the lexicon, albeit to a much lesser extent. The demarcation lines for the different constraints characterizing, for example, the native stratum do not always exactly coincide, resulting in the occurrence of items with mixed behavior. The existence of

such elements supports an important claim of our proposal: namely, that it is the individual constraint domains that are primary, not the stratal structure that emerges from them as a secondary generalization.[31] At the same time, a small set of items with mixed behavior does not alter the overwhelming generalization that structural properties show stratal clustering.

## 2 Optimality Theory and Lexical Core–Periphery Relations

Up to this point, our usage of the term "constraint" has been an informal, pretheoretic one. It is now time to be more precise in this respect. In particular, we need to clarify what it means for a given constraint to be "out of force" in certain areas of the lexicon. In Optimality Theory, the traditional notion of a parametrized constraint – something that can be turned "on" or "off" in grammars – is replaced by the notion that a grammar literally consists in imposing a ranking order on a given set of universal and violable constraints.[32] In this view, constraints are universal, uniformly present in all grammars; the effects of a given constraint differ from grammar to grammar depending on the placement of the constraint within the overall ranking. The "on/off" settings approach of earlier theories can be seen as a rough approximation to a more accurate theory based on the notions of ranking and violability.

For the case at hand, the question becomes how the core–periphery structure in (17) can be obtained with a uniform constraint set: how do the various areas of the lexicon differ, if they do not differ in terms of which constraints are "on" and which are "off"? The obvious suggestion is that they differ in the way the constraints are *ranked*. In pursuing this line of investigation, familiar considerations of restrictiveness suggest that we explore the possibility that there are strict limits on such lexicon-internal rerankings.[33] In Optimality Theory crucial aspects of the role of a particular constraint are determined by the way it is ranked with respect to the faithfulness constraints, including the three subfamilies prohibiting segment deletion (MAX), segment insertion (DEP), and change in feature value (IDENT).[34]

For a given wellformedness constraint (say, NOCODA), being ranked above some conflicting faithfulness constraints is roughly equivalent to being "on" in terms of traditional parameter setting; being ranked below all conflicting faithfulness constraints is roughly equivalent to being "off." In Optimality Theory, the "underlying inventory" of a certain language (segments, clusters, syllable types, etc.) is determined indirectly. Inputs themselves are not directly regulated; anything at all can in principle serve as an input; the grammar, as a system of ranked constraints, determines how, if at all, the input gets parsed.

Let us start with Prince and Smolensky's (1993) assumption of strict domination: every optimality-theoretic grammar imposes a total order on the set of constraints. Given constraints $A$ and $B$, either $A \gg B$ or $B \gg A$ must hold.

Taking a cue from the relation between the domains seen above in (16) and (17), it is natural to hypothesize that the four constraints under discussion are ranked as in (18).

(18) SYLLSTRUC
|
NO-DD
|
NO-P
|
NO-NT

In order to focus on the essential point, we abstract away from the differentiation between various Input/Output (henceforth, IO) constraints and consolidate the family of faithfulness conditions into a single unit (abbreviated as "FAITH"). Ranking FAITH below some constraint *C* means that *C* can command violations of faithfulness – at least one of the relevant faithfulness constraints is ranked below *C*. Likewise, ranking FAITH above some constraint *C* means that *C* cannot command violations of faithfulness – none of the relevant faithfulness constraints is ranked below *C*.[35]

The hierarchy in (18) suggests a very simple hypothesis about lexical stratification, namely, that it comes about through different rankings of faithfulness within a fixed hierarchy of structural wellformedness constraints. Consider the four wellformedness constraints under discussion. With their relative ranking fixed as in (18) above, there are five niches where FAITH can in principle be located, marked as $\text{FAITH}_1$ through $\text{FAITH}_5$ in (19). As indicated, $\text{FAITH}_1$–$\text{FAITH}_4$ indeed characterize the four vocabulary strata of Japanese under discussion.[36]

(19)
(←——— $\text{FAITH}_5$)
SYLLSTRUC
| ←——— $\text{FAITH}_4$ (= "FAITH/Unassimilated foreign")
NO-DD
| ←——— $\text{FAITH}_3$ (= "FAITH/Assimilated foreign")
NO-P
| ←——— $\text{FAITH}_2$ (= "FAITH/Sino-Japanese")
NO-NT
←——— $\text{FAITH}_1$ (= "FAITH/Yamato")

Working within the original version of Optimality Theory as developed in Prince and Smolensky (1993), Itô and Mester (1995a) conceive of $\text{FAITH}_1$–$\text{FAITH}_5$ as different rankings of the same block of IO- faithfulness constraints. Different strata involve slightly different grammars, and stratification is thus a form of linguistic variation. A variant of this proposal couched within Correspondence

Theory (McCarthy and Prince 1995) posits the different rankings of IO-FAITH as distinct replicas of IO-FAITH, each indexed for a vocabulary stratum (i.e. FAITH/Yamato, etc.). We will here present the theory in the indexed-FAITH format, and will later return to general questions raised by $\text{FAITH}_1$, etc.[37]

FAITH/Yamato ranks below all four wellformedness constraints in (19), with the consequence that it cannot interfere with their demands. When a faithfulness violation is preferred over violations of segmental, sequential, or syllabic well-formedness, we have core behavior: in Japanese, a characteristic of Yamato items.[38]

At the other end of the spectrum, top-ranking FAITH/Unassimilated foreign in (19) is subordinate to general syllable structure constraints. For example, Japanese disallows complex onsets and adheres to a very strict coda condition (see above) – hence the appearance of epenthetic vowels in loanwords where the loan source has a consonant cluster or a final coda. But since FAITH/Unassimilated foreign dominates the other three structural wellformedness constraints, faithfulness demands will be met at their cost. As shown in (20), *beddo*, *petto*, and *tento*, while taking a final epenthetic vowel[39] to meet syllable structure demands, faithfully preserve their voiced geminate, singleton-*p*, and nasal + voiceless obstruent cluster, respectively, in violation of the lower-ranking structural constraints.

(20) Unassimilated foreign:

| beddo "bed" (violation of No-DD) | | petto "pet" (violation of No-P) | | tento "tent" (violation of No-NT) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SYLLSTRUC | FAITH/Unassimilated foreign | NO-DD | ... | NO-P | ... | NO-NT | ... |
| /bed/ | [bed] | *! | | | | | | | |
| Unassimilated foreign | ☞ [beddo] | | * (DEP) | * | | | | | |
| | [betto] | | **! (DEP, IDENT-F) | | | | | | |
| /pet/ | [pet] | *! | | | | * | | | |
| Unassimilated foreign | ☞ [petto] | | * (DEP) | | | * | | | |
| | [hetto] | | **! (DEP, IDENT-F) | | | | | | |
| /tent/ | [tent] | *! | | | | | | * | |
| Unassimilated foreign | ☞ [tento] | | * (DEP) | | | | | * | |
| | [tendo] | | **! (DEP, IDENT-F) | | | | | | |

The candidate [beddo] is more faithful to /bed/ than [betto], which has an IDENT (i.e. change of feature value) violation in addition to a DEP (epenthesis) violation.[40]

As Katayama (1998) points out for similar cases, nothing much hinges on the choice of underlying forms. Besides /bed/, /pet/, and /tent/, another

possibility is /beddo/, /petto/, /tento/, i.e. with lexically encoded epenthetic vowels, as shown in (21). In the absence of alternations, a version of lexicon optimization that puts a higher value on input–output similarity than on input simplicity in fact selects the latter set as the optimal input forms.[41]

(21)

| | | SYLLSTRUC | FAITH/ Unassimilated foreign | NO-DD | ... | NO-P | ... | NO-NT | ... |
|---|---|---|---|---|---|---|---|---|---|
| /beddo/ Unassimilated foreign | ☞ [beddo] | | | * | | | | | |
| | [betto] | | *! (IDENT-F) | | | | | | |
| /petto/ Unassimilated foreign | ☞ [petto] | | | | | * | | | |
| | [hetto] | | *! (IDENT-F) | | | | | | |
| /tento/ Unassimilated foreign | ☞ [tento] | | | | | | | * | |
| | [tendo] | | *! (IDENT-F) | | | | | | |

One step down the ladder in (19), we find FAITH/Assimilated foreign, which differs from FAITH/Unassimilated foreign only in being subordinate to the voiced geminate obstruent constraint NO-DD. Avoidance of voiced obstruent geminates is therefore a high priority, as far as the nativization of loanwords is concerned.[42] The result is illustrated in (22).

(22) Unassimilated foreign: beddo "bed" (violation of NO-DD)

Assimilated foreign: (hando)bakku "handbag"[43] (no violation of NO-DD, violation of FAITH/Assimilated foreign)

| | | FAITH/ Unassimilated foreign | NO-DD | FAITH/ Assimilated foreign | NO-P | ... | NO-NT | ... |
|---|---|---|---|---|---|---|---|---|
| /beddo/ Unassimilated foreign | ☞ [beddo] | | * | | | | | |
| | [betto] | *! (IDENT-F) | | | | | | |
| /baggu/ Assimilated foreign | [baggu] | | *! | | | | | |
| | ☞ [bakku] | | | *! (IDENT-F) | | | | |
| /pabbu/ Assimilated foreign | [pabbu] | | *! | | * | | | |
| | ☞ [pabu] | | | * (IDENT-μ) | * | | | |
| | [habu] | | | **! (IDENT-F,μ) | | | | |
| | [habbu] | | *! | * (IDENT-F) | | | | |

With respect to the other two constraints, No-P and No-NT, Faith/Assimilated foreign remains dominant, thus forestalling any changes leading to the avoidance of singleton-*p* or of nasal+voiceless obstruent clusters. This is illustrated in (22) for the loanword *pabu* "pub" with its possible input /pabbu/: while parsing the *b* non-moraically, which is one way of avoiding the otherwise expected geminate, is legitimized by this ranking of Faith, debuccalizing *p* to *h*, which would lead to a more fully nativized form *habu*, is forestalled by faithfulness.

In (23), we define the individual faithfulness constraints violated in the tableaux above.

(23) Let *s* and *s'* be two segments that are correspondents of each other, and let *P(x)* denote the specification status of segment *x* with respect to some property *P* (e.g. [+continuant], [−continuant], or [0continuant]; [0μ], [1μ], or [2μ], etc.).[44]

a. Ident-F: *F(s) = F(s')*. "Correspondent segments have identical specifications for feature F."

b. Ident-μ: *μ(s) = μ(s')*. "Correspondent segments have the same moraicity."

Returning to the hierarchy of indexed Faith (19), we find Faith/Sino-Japanese ranked below SyllStruc, No-DD, and No-P, but still above No-NT. This means that an input sequence like /...nt.../ will be parsed as such in the output, in violation of No-NT, but the other three constraints can all command violations of Faith/Sino-Japanese. In particular, singleton-*p* cannot surface in Sino-Japanese.

(24) Assimilated foreign: paN "bread" (violation of No-P) Sino-Japanese: haN "group" (no violation of No-P)

| | | ... | No-DD | Faith/ Assimilated foreign | No-P | Faith/ Sino-Japanese | No-NT | ... |
|---|---|---|---|---|---|---|---|---|
| /paN/ Assimilated foreign | ☞ [paN] | | | | * | | | |
| | [haN] | | | *! | | | | |
| /paN/ Sino-Japanese | [paN] | | | | *! | | | |
| | ☞ [haN] | | | | | * | | |

Thus the word for *bread* surfaces as [paN] (cf. Portuguese *pão*), but the Sino-Japanese morpheme /paN/ "group" is realized as [haN] (cf. *ippaN* "group one," *sampaN* "group 3").

Finally, (25) contrasts Sino-Japanese and Yamato items with respect to the low-ranking constraint No-NT.

(25) Sino-Japanese: šin-tai "body" (violation of No-NT) Yamato: šin-de "die-Gerund" (no violation of No-NT)

| | | ... | *No-DD* | ... | *No-P* | *Faith/ Sino-Japanese* | **No-NT* | *Faith/ Yamato* |
|---|---|---|---|---|---|---|---|---|
| /šiN-tai/ Sino-Japanese | ☞ [šiNtai] | | | | | | * | |
| | [šiNdai] | | | | | *! | | |
| /šiN-te/ Yamato | [šiNte] | | | | | | *! | |
| | ☞ [šiNde] | | | | | | | * |

Stepping back from the details of this sketch of the stratal grammar of Japanese, we see that the simple hypothesis that stratal variation is due to the ranking of faithfulness and nothing else appears to provide enough descriptive flexibility to account for the empirical facts of stratification while at the same time imposing tight limits on the types of divergence allowed between strata. Ranked and violable faithfulness constraints are essential for this enterprise, just as in other areas. Optimality Theory allows us to reduce what looks like a haphazard application of constraints in different strata to a simple model, viz. a single phonology with a unique set of ranked structural constraints, with stratally indexed faithfulness constraints interleaved at different points.[45]

# 3 Developing Grammars and Stratification

The theory advocated here receives further support from the predictions it makes regarding possible nativizations. In this section, we first lay out the evidence and its implications (section 3.1). Building on these findings and recent results in Optimality Theory, we consider how stratification arises in the development of a grammar with diversified faithfulness, starting from an initial state where all faithfulness constraints are ranked below all markedness constraints (section 3.2).

## *3.1 Possible and impossible nativizations*

There are significant restrictions on the ways in which native and non-native properties can be combined in partial nativizations, as shown in several studies, including Holden (1976) for Russian and Itô and Mester (1995a: 201–4) for Japanese. As the latter authors note, given a particular grammar and hence a

specific ranking of the structural constraints, impossible nativization patterns constitute a crucial argument for the optimality-theoretic approach to stratification advocated here.

A concrete example from Itô and Mester (1995b: 832–3) illustrates the basic point about impossible nativizations. The palatalization constraints on fricatives and plosives of Japanese (here informally abbreviated as *SI and *TI; see the work cited for formal statements) result in the replacements *si* → *ši* and *ti* → *či*, giving rise to well-known alternations, e.g. *kas-e* "lend-Imperative," *kaš-i* "a loan;" *kat-e* "win-Imperative," *kač-i* "a win." However, there is one crucial difference between the two palatalization constraints: whereas the fricative-targeting constraint *SI is enforced in practically all recent loans, the plosive-targeting version *TI is not. Thus "sea" is *šii* and not **sii*, but "party" is *paatii* and not **paačii*. Palatalizing the fricative is more important than palatalizing the plosive, or in optimality-theoretic terms, the ranking must be as in (26), with other constraint(s) crucially intervening.

(26) *SI
⋮
*TI

Given (26) and the input form /siti/, with both consonants nonpalatalized, the system correctly predicts that *siti*, *šiti*, and *šiči*, but not *siči*, are possible nativizations of "city." The outcome depends on the stratum and its concomitant FAITH, as shown in (27). The second is the one usually encountered, as in the name *šitibaŋku* "Citibank."

(27)

| | | FAITH/X | *SI | FAITH/Y | *TI | FAITH/Z |
|---|---|---|---|---|---|---|
| a. /siti/ [stratum: Z] | ☞ [šiči] | | | | | ** |
| | [šiti] | | | | *! | * |
| | [siti] | | *! | | * | |
| | [siči] | | *! | | | * |
| b. /siti/ [stratum: Y] | [šiči] | | | **! | | |
| | ☞ [šiti] | | | * | * | |
| | [siti] | | *! | | * | |
| | [siči] | | *! | * | | |
| c. /siti/ [stratum: X] | [šiči] | **! | | | | |
| | [šiti] | *! | | | * | |
| | ☞ [siti] | | * | | * | |
| | [siči] | *! | * | | | |

X, Y, and Z roughly correspond to "unassimilated," "assimilated," and "native," respectively. When the input is indexed for FAITH/Z, which is positioned below both *SI and *TI, we get the fully nativized *šiči* (27a), with double palatalization. This is found, for example, in the brand-name "Citizen," whose proper pronunciation is *šičizun*. When the input is indexed for FAITH/X, which is positioned above both markedness constraints, the unassimilated *siti* wins (27c), without any palatalization; and when it is indexed for FAITH/Y, which intervenes between the two constraints, the partially assimilated *šiti* emerges victorious (27b), with mixed palatalization behavior. Crucially, the candidate *siči*, which shows the other possible mix of palatalization properties, can never be the winner, given the input /siti/. In fact, in (27a–c) *siči* is not just non-optimal in individual competitions, but is a perpetual loser – it is always bettered by some other candidate. Because of the ranking of the sequential markedness constraints *SI ≫ *TI, there is no way to rank some FAITH/α in such a way that *siči* wins at stratum α. The input–output pairing /siti/~[siči] is therefore harmonically bounded (cf. Prince and Smolensky 1993: 176–8), and is impossible as a nativization of a form containing both *si* and *ti*. In order for a winning output candidate to contain *s* before *i*, it must be the case that FAITH/X ≫ *SI. Given *SI ≫ *TI, this implies FAITH/X ≫ *TI by transitivity. In other words, once the sequence *si* is protected by faithfulness, *ti* is protected as well. By similar reasoning we determine that once *ti* is ruled out by markedness, so is *si* (*SI ≫ *TI ≫ FAITH/Z). The sequences *ti* and *si* can be treated differently only in the way instantiated by *šiti* (*SI ≫ FAITH/Y ≫ *TI). Given the central hypothesis of the core–periphery model, viz. that there is only a stratal replication of faithfulness and no stratal replication of structural constraints in the lexicon, no ranking selects *siči* as the best way of parsing /siti/, since this would require *TI ≫ FAITH/W ≫ *SI – which cannot coexist with *SI ≫ . . . ≫ *TI.

The **siči*-effect is a concrete illustration of a point made earlier (see (3) and (16)), namely, that the optimality-theoretic core–periphery model captures the implicational relations holding within the phonological lexicon.[46] Comparable to *siči* as an impossible nativization on the basis of the input /siti/ is the form *habbu* considered earlier in (22) as an output candidate at the Assimilated foreign stratum for the input /pabbu/ "pub." With preservation of the voiced obstruent geminate and debuccalization of *p* to *h* in order to avoid a singleton-*p*, the input–output pairing /pabbu/~[habbu] resembles /siti/~[siči] in showing an ill-fated combination of properties. Given NO-DD ≫ NO-P, there is no place in the hierarchy where some FAITH/α could be ranked so that *habbu* wins at stratum α – in other words, different from the other candidates (*pabu, pabbu, habu*), *habbu* is impossible as a nativization relative to the input /pabbu/.[47]

Impossible nativizations are useful as a test for different theories of stratal organization. Let us compare the stratal indexation model developed here with an approach which attempts to distinguish strata exclusively by means of input (pre)specification vs. underspecification for a given property.[48] If the core–periphery status of an item is formally expressed by degree of

specification, this means, roughly speaking, that peripheral items need more specifications to counteract feature- and structure-filling defaults. Whether in a classic rule-based setting or in an optimality-theoretic environment, such a model can certainly express the core–periphery distribution of individual properties within the lexicon. However, since (pre/under)specification in one place is independent of (pre/under)specification in another place, the higher-level task of accounting for implicational dependencies *between* properties (e.g. the **siči*-effect) remains unsolved and would require extra machinery.[49] This shortcoming, which we will now exemplify more concretely, is a by-product of the independence of specifications, which introduces too many degrees of freedom into the system.

Let us assume, for concreteness, that nonpalatalizability of consonants is expressed by specifying [+anterior] in the input. The actual feature or structure that is used does not matter for the purpose of the argument; what matters is that the input specifications must be protected by faithfulness. All relevant faithfulness constraints must rank above the markedness constraints concerned with the ban against [+anterior] coronals preceding high front vowels, schematically: FAITH ≫ {*SI, *TI, . . . }. For the example under discussion, we have now the four representations in (28), where capital letters denote segments not specified for the feature anterior.[50]

(28) a. S i T i
[šiči]

b. [+ant]
S i T i
[šiti]

c. [+ant] [+ant]
S i T i
[siti]

d. [+ant]
S i T i
[siči]

(29)

| | | FAITH | *SI | *TI |
|---|---|---|---|---|
| a. /S i T i/ | ☞ [šiči] | ** | | |
| | [šiti] | ** | | *! |
| | [siti] | ** | *! | * |
| | [siči] | ** | *! | |
| b. [+ant] /S i T i/ | [šiči] | **! | | |
| | ☞ [šiti] | * | | * |
| | [siti] | * | *! | * |
| | [siči] | **! | * | |
| c. [+ant] [+ant] /S i T i/ | [šiči] | *!* | | |
| | [šiti] | *!* | | * |
| | ☞ [siti] | | *! | * |
| | [siči] | *!* | *! | |

(29)

| d. [+ant] \| /S i T i/ | [šiči] | **! | | |
|---|---|---|---|---|
| | [šiti] | **! | | * |
| | ☞ [siti] | * | * | *! |
| | [siči] | * | * | |

The trouble is with representation (28d), which leads directly to the impossible nativization **sičči*, as tableau (29d) verifies.[51] We cannot remedy the problem by ranking FAITH between *SI and *TI: *SI ≫ FAITH ≫ *TI, since this would not work for the native stratum, where palatalization of *t* before *i* is obligatory as well. One could try to overcome this problem by differentiating faithfulness in terms of strata: *SI ≫ FAITH/Y ≫ *TI ≫ FAITH/Z. But this move amounts to conceding the point that is at issue, viz. that input (pre/under)specification is insufficient to express stratal structure in the lexicon. In addition, the crucial dependency is still not expressed: whenever the sequence [si] is tolerated in a possible nativization, the sequence [ti] is as well, but not necessarily vice versa. In order to account for this, FAITH/X has to be added at the top of the hierarchy, replicating the entire ranking in (27). The analytical burden has shifted entirely to the stratal faithfulness constraints and their ranking, and (pre/under)specification ([+anterior] vs. [0anterior]) no longer plays a decisive role in distinguishing strata.[52]

On the other hand, in the model with stratum-indexed faithfulness constraints advocated here, such dependencies, and the resulting distinction between possible and impossible nativizations, are a consequence of a fundamental property of optimality-theoretic grammars, namely, the strict ranking of constraints.

## 3.2 *The initial state, ranking conservatism, and ranking consistency*

The details of the analysis of the multi-stratal vocabulary of Japanese raise some further important theoretical questions pertaining to the formal structure of faithfulness constraints. One of the central points of this chapter is that stratification in the lexicon shows an interesting subset structure. Strata are arrayed in a core–periphery manner, such that given two strata *A* and *B*, either the structures possible at *A* form a proper subset of the structures possible at *B*, or vice versa. This empirical generalization follows directly from our optimality-theoretic conception of the lexicon, which understands stratification as the result of different rankings of a block of FAITH constraints within a fixed hierarchy of structural constraints.

The specific account presented so far makes one simplifying assumption about the ranking of faithfulness constraints: all faithfulness constraints relevant to the markedness constraints NO-DD, NO-P, etc., such as IDENT-μ (checking the moraic value of correspondent segments), IDENT-PLACE (enforcing place

feature identity between correspondent segments), are taken to be consolidated in FAITH/X, etc. (where X is a lexical class), so that strata are carved out by uniform indexations of the whole block of faithfulness constraints.

(30) Input: /pabbu/

| Ranking: | | | | | | Output |
|---|---|---|---|---|---|---|
| a. | NO-DD | ≫ | NO-P | ≫ | "FAITH/$_A$": {ID-PL/$_A$, ID-μ/$_A$} (etc.) | [habu] |
| b. | NO-DD | ≫ | "FAITH/$_B$": {ID-PL/$_B$, ID-μ/$_B$} (etc.) | ≫ | NO-P | [pabu] |
| c. | "FAITH/$_C$": {ID-PL/$_C$, ID-μ/$_C$} (etc.) | ≫ | NO-DD | ≫ | NO-P | [pabbu] |

Let us now remove this "faithfulness block" idealization, which is not as harmless as it might appear, and assume that the various indexed instantiations of the individual micro-constraints, such as IDENT-PLACE (enforcing place feature identity between correspondent segments) and IDENT-μ (checking the moraic value of correspondent segments), are independently rankable, as shown in (31), where the rankings are sorted by the output form that they select. The ranking of the markedness constraints is fixed as NO-DD ≫ NO-P, as before, and the additional rankings common to each group are given in the leftmost column.

(31) Ranking of markedness constraints fixed as: NO-DD ≫ NO-P
Input: /pabbu/

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| a. | NO-DD ≫ ID-μ/$_A$<br>ID-PL/$_A$ ≫ NO-P | i. | NO-DD | ID-μ/$_A$ | ID-PL/$_A$ | NO-P | ☞ pabu |
| | | ii. | NO-DD | ID-PL/$_A$ | ID-μ/$_A$ | NO-P | ☞ pabu |
| | | iii. | NO-DD | ID-PL/$_A$ | NO-P | ID-μ/$_A$ | ☞ pabu |
| | | iv. | ID-PL/$_A$ | NO-DD | ID-μ/$_A$ | NO-P | ☞ pabu |
| | | v. | ID-PL/$_A$ | NO-DD | NO-P | ID-μ/$_A$ | ☞ pabu |
| b. | ID-μ/$_B$ ≫ NO-DD<br>ID-PL/$_B$ ≫ NO-P | i. | ID-μ/$_B$ | NO-DD | ID-PL/$_B$ | NO-P | ☞ pabbu |
| | | ii. | ID-μ/$_B$ | ID-PL/$_B$ | NO-DD | NO-P | ☞ pabbu |
| | | iii. | ID-PL/$_B$ | ID-μ/$_B$ | NO-DD | NO-P | ☞ pabbu |
| c. | NO-DD ≫ ID-μ/$_C$<br>NO-P ≫ ID-PL/$_C$ | i. | NO-DD | ID-μ/$_C$ | NO-P | ID-PL/$_C$ | ☞ habu |
| | | ii. | NO-DD | NO-P | ID-PL/$_C$ | ID-μ/$_C$ | ☞ habu |
| | | iii. | NO-DD | NO-P | ID-μ/$_C$ | ID-PL/$_C$ | ☞ habu |
| d. | ID-μ/$_D$ ≫ NO-DD<br>NO-P ≫ ID-PL/$_D$ | i. | ID-μ/$_D$ | NO-DD | NO-P | ID-PL/$_D$ | ☞ habbu |

Table (31) demonstrates two important points. First, the ranking of the four constraints is to a considerable degree undetermined since three of the four mappings can be obtained with more than one ranking: *pabu* (31a) is derived by five rankings, *pabbu* (31b) and *habu* (31c) by three each. Second, besides the structurally possible realizations (from least to most nativized) *pabbu*, *pabu*, and *habu* (31a–c) for the input /pabbu/, the system now also produces the impossible nativization *habbu* (31d) (cf. (22) above, and the discussion in section 3.1 in connection with the *sičí*-effect).

The latter result is a serious problem since it deprives the model of its central empirical prediction (namely, the existence of a characteristic core–periphery structure). It is therefore important for future research to consider ways to preserve the theory's predictive power. The explosive growth of ranking possibilities comes about through the step of individualizing the faithfulness component into separate and mutually independent micro-constraints. However, reverting to the simplicity of (30) by consolidating all faithfulness into a single monolithic unit (i.e. in effect denying the diversification of faithfulness constraints) is unlikely to be successful. Attractive though it might seem from the perspective of conceptual restrictiveness, it is incompatible with the collective results of recent analytical work in Optimality Theory, which demonstrate quite clearly that the faithfulness component of the constraint system needs a considerable amount of flexibility.[53]

In this situation, it might be useful to ask the more modest question of what must minimally be true about the relative ranking of indexed faithfulness constraints in order for the situation in (31) not to arise. The task is therefore to secure the results regarding possible and impossible nativizations while maintaining full diversification of the faithfulness component. Since this topic is clearly beyond the scope of this chapter, we will here restrict our remarks to a few pointers in the direction of future research in the remainder of this section. Our proposal consists of three elements: (i) a requirement demanding ranking consistency for IO-faithfulness constraints (32), (ii) an M $\gg$ F structure for the initial state of the grammar ((35) and Smolensky 1996), and (iii) Ranking Conservatism (36) as a guiding principle for successive stages of a developing grammar. As will be seen, the core–periphery model can be significantly enhanced by embedding it in the context of learnability and grammar development considerations.

First, we impose a consistency condition on the relative rankings of the different stratal representatives of individual faithfulness constraints.[54]

(32) *Ranking Consistency:*
Let F and G be two types of IO-faithfulness constraints (e.g. IDENT-PLACE and IDENT-μ).
Then the relative rankings of the indexed versions of F and G are the same across all strata: $\forall AB\ (F/_A \gg G/_A) \Rightarrow (F/_B \gg G/_B)$.

Thus, if $F/_A \gg G/_A$ holds for some stratum *A*, then $F/_B \gg G/_B$ must hold for every stratum *B*. In other words, there is a sense in which the ranking of the

various types of faithfulness constraints is fixed across all indexed instantiations, just as the ranking of structural constraints – namely, insofar as the ranking of faithfulness constraints with respect to each other is concerned.[55] This is schematically shown in (33).

(33) $R(Con_M)$: $M^1 \gg M^2 \gg M^3 \gg M^4$ $\quad R(Con_F)$: $F^1 \gg F^2 \gg F^3$

Variation is confined to the ranking of individual faithfulness constraints with respect to individual structural constraints. In this view, instead of thinking of a grammar as a ranking R(Con) of a universal constraint set Con, it is more adequate to conceive of it as comprising (i) a ranking $R(Con_F)$ of a universal set of faithfulness constraint types $Con_F$, (ii) a ranking $R(Con_M)$ of a universal set of structural markedness constraints $Con_M$, and (iii) different intercalations of the faithfulness constraint hierarchy $R(Con_F)$ with the structural constraint hierarchy $R(Con_M)$. Each such intercalation defines a stratum, consisting of $R(Con_M)$ and indexed copies of the faithfulness constraints in $Con_F$, respecting the ranking in $R(Con_F)$.[56]

(34) $R(Con_M)$: $M^1 \gg M^2 \gg M^3 \gg M^4$ $\quad R(Con_F)$: $F^1 \gg F^2 \gg F^3$

a. Stratum *X*: $M^1 \gg M^2 \gg M^3 \gg M^4 \gg F^1 \gg F^2 \gg F^3$

conflated into a single hierarchy: $M^1 \gg M^2 \gg M^3 \gg M^4 \gg F^1_X \gg F^2_X \gg F^3_X$

b. Stratum *Y*: $M^1 \gg M^2 \gg F^1 \gg M^3 \gg F^2 \gg M^4 \gg F^3$

conflated into a single hierarchy: $M^1 \gg M^2 \gg F^1_Y \gg M^3 \gg F^2_Y \gg M^4 \gg F^3_Y$

c. all strata conflated into a single hierarchy: $M^1 \gg M^2 \gg F^1_Y \gg M^3 \gg F^2_Y \gg M^4 \gg F^3_Y, F^1_X \gg F^2_X \gg F^3_X$

The second ingredient of our proposal is Smolensky's (1996) hypothesis that in the initial state $\mathcal{H}_0$ of grammar acquisition all faithfulness constraints are subordinated to all markedness constraints, as schematically expressed in (35).[57]

(35) *Initial State* $\mathcal{H}_0$: $M \gg F$ (Markedness $\gg$ Faithfulness)

Finally, we assume that in developing and expanding a grammar, the dominance relations of each state are preserved as much as possible in the next state, i.e. grammar change is minimal. This is expressed as the principle of Ranking Conservatism in (36).

(36) *Ranking Conservatism:*
In expanding the grammar (for example, by diversifying faithfulness constraints by stratal indexation), dominance relations of the current state $\mathcal{H}_i$ are maximally preserved in the subsequent state $\mathcal{H}_{i+1}$.

In (37), we formulate a special application of Ranking Conservatism which concerns the ranking of stratally indexed versions of some faithfulness constraint F.

(37) *Ranking Inheritance* (a special case of Ranking Conservatism):
The stratal representatives $F/_A, \ldots, F/_Z$ in state $\mathcal{H}_{i+1}$ corresponding to an undiversified faithfulness F in state $\mathcal{H}_i$ each maximally inherit F's ranking relations with respect to other constraints.

The main idea behind the overall proposal, consisting of Ranking Consistency (32), an initial state with M ≫ F (35), and Ranking Conservatism (36), is the following: conservatism with respect to the initial state $\mathcal{H}_0$ entails that a later state $\mathcal{H}_i$, even though deviating from the original M ≫ F pattern, still inherits, as the residue of $\mathcal{H}_0$'s subordination of *every* faithfulness constraint to *every* markedness constraints, a general low ranking of faithfulness constraints with respect to markedness constraints (*ceteris paribus*, i.e. except where contradicted by overt evidence and possibly other ranking principles). For $\mathcal{H}_i$, this singles out a specific articulation of the constraint hierarchy (among other possibilities that are also compatible with the data under consideration), with induced M–M dominance relations between different markedness constraints and F–F dominance relations between different faithfulness constraints. Through Ranking Conservatism (36) and Ranking Consistency (32), these relations become a fixed property of the grammar. Certain unattested rankings are in this way excluded, and we will see that this makes many input–output mappings unreachable as nativization patterns.

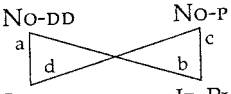
In order to illustrate the proposal with a concrete example, we take up the markedness constraints and faithfulness constraints discussed earlier in (30)–(31). For the four constraints under consideration (though not for others), we can, for purposes of presentation, identify the core grammar of Japanese with the initial state $\mathcal{H}_0$, with markedness constraints reigning supreme. This is shown in (38), where the M-constraints (No-DD and No-P) are ranked higher than F-constraints (Ident-μ, Ident-Pl).

(38) $\mathcal{H}_0$: {No-DD, No-P}
≫
{Ident-μ, Ident-Pl}

The four separate dominance relations asserted in (38), individually listed in (39a–d), are more explicitly depicted in (40).

(39) a. No-DD ≫ Id-μ
b. No-DD ≫ Id-Pl
c. No-P ≫ Id-Pl
d. No-P ≫ Id-μ

(40) $\mathcal{H}_0$: No-DD — No-P (Markedness)
Id-μ — Id-Pl (Faithfulness)




With the initial state grammar (40), the mapping /pabbu/ → [habu] emerges due to high-ranking No-P and No-DD.

Now suppose that, in the process of expanding the grammar so as to deal with loan vocabulary and other peripheral items, additional mappings have to be mastered that lead to more faithful (and hence in general more marked) outputs. In order to keep things simple, we will use /pabbu/ → [pabu] to represent such mappings. In cases of a stratally organized lexicon, as discussed in earlier sections, the acquisition of such more faithful mappings does not lead to a wholescale overwriting of the core grammar, as it exists up to this point. New mappings are instead accommodated by the addition of a separate stratum, leaving the more central areas of the lexicon unaffected. Put in classical phonemic terms (see C. C. Fries and Pike 1949), it is a fallacy to conclude from the fact that "*x* is a phoneme" holds for foreign loans in Japanese that "*x* is a phoneme" must be true everywhere in Japanese.[58]

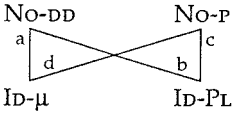
Stratal diversification of the faithfulness system means that the coexistence of the two mappings in (41) has to be dealt with (where /pabbu/$_N$ and /pabbu/$_{AF}$ are schematic examples of input forms of different lexical items, belonging to the native and the assimilated foreign stratum, respectively).

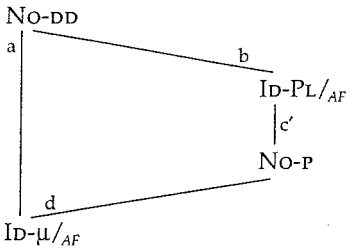
(41) a. /pabbu/$_N$ → [habu] b. /pabbu/$_{AF}$ → [pabu]

In order to select [pabu] as the output for /pabbu/$_{AF}$, it must be the case that in the grammar of the new state $\mathcal{H}_1$ in (42), faithfulness to the place feature Ident-Pl/$_{AF}$ dominates No-P (42c′), different from the situation in $\mathcal{H}_0$ (see (42c) and (39)).

(42) a. No-DD ≫ Id-μ
b. No-DD ≫ Id-Pl
c. ~~No-P ≫ Id-Pl~~ c′. Ident-Pl/$_{AF}$ ≫ No-P
d. No-P ≫ Id-μ

We have already seen in (31) that several overall rankings are able to produce the mapping /pabbu/ → [pabu]. Among these, Ranking Conservatism (36) singles out one ranking for the AF stratum, namely the ranking that is maximally similar to $\mathcal{H}_0$ (repeated in (43) for ease of comparison).[59] The rankings relevant for the new stratum in (44) preserve the $\mathcal{H}_0$-rankings (43a–b, 43d), but (42c′) Ident-Pl/$_{AF}$ ≫ No-P takes the place of (42c) No-P ≫ Id-Pl.

(43) $\mathcal{H}_0$: 


(44) 


(44) is equivalent to the strict ranking in (45), which incorporates the two new induced ranking relations in (46). Id-Pl/$_{AF}$ ≫ No-P (44c′) and No-P ≫ Id-μ/$_{AF}$ (44d) give rise to the induced FF-ranking Id-Pl/$_{AF}$ ≫ Id-μ/$_{AF}$ (46b), and No-DD ≫ Id-Pl/$_{AF}$ (44b) and Id-Pl/$_{AF}$ ≫ No-P (44c′) given rise to the induced MM-ranking No-DD ≫ No-P (both by transitivity).

(45) Rankings relevant for AF-stratum:

No-DD
|
Id-Pl/$_{AF}$
|
No-P
|
Id-μ/$_{AF}$

(46) Induced ranking relations:
a. MM-ranking: No-DD ≫ No-P
b. FF-ranking Id-Pl/$_{AF}$ ≫ Id-μ/$_{AF}$

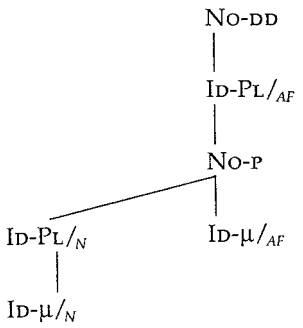
(46a) highlights an advance of the new theory over the version presented earlier in this chapter. Instead of having to postulate MM-rankings such as No-DD ≫ No-P as givens, they are now seen to emerge in a systematic way in the process of grammar development. The crucial factor is that mappings of the type /pabbu/ → [pabu], which preserve singleton-*p* in the winning output, while not part of the core lexicon, appear reasonably early in the process of grammar development (presumably, due to the statistical frequency of such forms in contemporary Japanese) – earlier than unassimilated foreign mappings such as /pabbu/$_{UF}$ → [pabbu] which preserve the voiced obstruent geminate in the output. This order of events is eminently plausible, given the truly marginal status of voiced obstruent geminates in the sound pattern of Japanese, but, needless to say, the point deserves further empirical scrutiny.

As for the ranking relation between the two faithfulness constraints in (46b), Consistency (32) projects it to all strata, as in (47), which must hold for all strata *X*, including *X* = Native. Combining the AF-ranking for the assimilated foreign stratum in (45) with the earlier $\mathcal{H}_0$ state for the core lexicon in (43)

(from the current viewpoint, an N-ranking), we obtain (48) as the $\mathcal{H}_1$ state of the full grammar.

(47) Id-Pl/$_X$ ≫ Id-μ/$_X$

(48) $\mathcal{H}_1$:

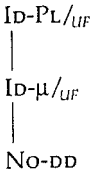



The next step is the acquisition of a third stratum for unassimilated foreign items ("UF"), here schematically represented by the hyper-faithful mapping /pabbu/$_{UF}$ → [pabbu]. In the overall language, we have a coexistence of three mappings (49).

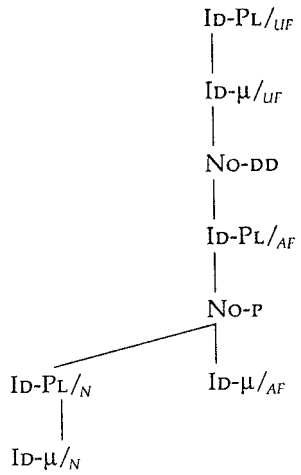
(49) a. /pabbu/$_N$ → [habu] b. /pabbu/$_{AF}$ → [pabu]
c. /pabbu/$_{UF}$ → [pabbu]

(49c) means that UF-faithfulness must allow voiced obstruent geminates to be faithfully parsed, calling for Id-μ/$_{UF}$ ≫ No-dd. We know already from (47) that Id-Pl/$_X$ ≫ Id-μ/$_X$ must hold for all strata X, including X = UF. These considerations together dictate the subhierarchy (50) for the unassimilated foreign stratum. Combining this with the $\mathcal{H}_1$-grammar in (48), we obtain the $\mathcal{H}_2$-grammar in (51) for the full language.

(50)




(51) $\mathcal{H}_2$:



Let us now return to our central issue, namely, impossible nativizations. Continuing with our example, we will show that, once the system has been modified so as to accommodate the mapping /pabbu/$_{AF}$ → [pabu], it is *not* (or only at a considerable cost) able to accommodate mappings of the kind /pabbu/$_{X}$ → [habbu], for some stratum *X*.

The two crucial rankings necessary to achieve the mapping /pabbu/$_{X}$ → [habbu] are given in (52).

(52) Ident-μ/$_{X}$ ≫ No-DD (to preserve the voiced geminate)
No-P ≫ Ident-Pl/$_{X}$ (to change the labial place specification).

Among the 4! = 24 rankings of the four constraints {No-P, Ident-Pl, Ident-μ, No-DD}, 6 rankings are compatible with (52). They are listed in (53).

(53) Rankings resulting in the mapping /pabbu/$_{X}$ → [habbu]:
a. Ident-μ ≫ No-DD ≫ No-P ≫ Ident-Pl } incompatible with Ident-Pl ≫ Ident-μ
b. No-P ≫ Ident-Pl ≫ Ident-μ ≫ No-DD } incompatible with No-DD ≫ No-P
c. Ident-μ ≫ No-P ≫ Ident-Pl ≫ No-DD
d. Ident-μ ≫ No-P ≫ No-DD ≫ Ident-Pl } incompatible with both Ident-Pl ≫ Ident-μ and No-DD ≫ No-P
e. No-P ≫ Ident-μ ≫ Ident-Pl ≫ No-DD
f. No-P ≫ Ident-μ ≫ No-DD ≫ Ident-Pl

However, as seen in (46), the acquisition of assimilated foreign mapping /pabbu/$_{AF}$ → [pabu] earlier in the grammar development process has fixed the MM-ranking between the two markedness constraints and the FF-ranking between the two faithfulness constraints as No-DD ≫ No-P and Ident-Pl ≫ Ident-μ, respectively. Each one of the six rankings in (53) is incompatible with at least one of these rankings: (53a) is incompatible with the faithfulness ranking, (53b) with the markedness ranking, and (53c–f) with both rankings. Ranking Consistency thus predicts that, given the prior establishment of the rankings yielding the mapping /pabbu/ → [pabu], there is no simple stratal extension of a grammar yielding the mapping /pabbu/ → [habbu]. The latter is thus not possible as a nativizing mapping in the sense of section 3.1.[60] In this way, given a few general assumptions about the initial state and the course of grammar development, early steps in the acquisition process automatically impose limitations on all subsequent steps, explaining the phenomenon of "impossible nativizations."

## 4 Summary and Directions for Future Research

This chapter has presented an overview of the organization of the phonological lexicon of Japanese, focusing on questions relating to the segment

inventory (such as the occurrence of singleton-*p*) and sequential conditions (such as postnasal voicing or palatalization). As in earlier work on this topic, the traditional subdivisions (such as Yamato, Sino-Japanese, and Western loans with various degrees of assimilation) are seen to play a major role. Generalizing over many individual cases and phenomena, an overall core–periphery picture emerges which calls for a systematic account in the context of a coherent theory.

After a brief critical examination of earlier theories, a general optimality-theoretic model of the phonological lexicon is put forth which aims to account for differences between strata within a unitary constraint system. The central hypothesis asserts that stratum-specific input–output faithfulness constraints are necessary and sufficient to account for the stratal organization of a language's lexicon. We show that stratally indexed faithfulness, but not alternative input specification/underspecification approaches, is able to capture crucial higher-level implicational relations between nativization effects, thus deriving the existence of a core–periphery structure in the lexicon from basic tenets of Optimality Theory, without additional mechanisms.

Finally, the chapter attempts to point out some avenues for further research by recasting the issues within the context of recent optimality-theoretic work on the acquisition and development of grammars. Such a move makes it possible to sharpen the proposal and to derive important generalizations and restrictions regarding the rankings of individual stratum-specific faithfulness constraints. If pursued further, it promises to lead to a deeper understanding of the factors and principles involved in lexical stratification. For example, the stratal distinctions in the accentual system investigated by a number of researchers (Katayama 1995, 1998, Kubozono 1997, among others) cast additional light on these acquisition issues. Are the results of previous investigation compatible with the approach advocated here, and do they lead to new insights in this regard? Related questions concern forms that are stratal hybrids (Fukazawa et al. 1998, R. Walker 1998): when faithfulness constraints relating to different strata conflict with each other, is their competition resolved in the correct way through their independently established ranking? How does it interact with the FAITH(Root) ≫ FAITH(Affix) scheme of McCarthy and Prince (1995)? Certain details of the stratal organization of Japanese also remain to be worked out. Interesting issues arise, for example, regarding the proper treatment of mimetic items (Fukazawa 1998, Itô and Mester 1995a, 1995b, Spaelti 1998): do they constitute a separate stratum, or do they belong to the Yamato stratum? If the latter, what are the crucial factors that make the distinction? The issue is not merely a descriptive one since it bears on the general question of the limits of stratal organization (Inkelas et al. 1997): at what point does stratal structure become opaque, leading to a reduction of strata? The general answer must be that the point of restructuring is determined by general principles of grammar simplicity and optimization (see Kiparsky 1965 and later work). Fleshing out this general idea through concrete case studies is an important task for future work.

## Appendix: Faithfulness Schemata and Instantiations

The question to be addressed in this appendix is why only faithfulness constraints – and not structural constraints – can be indexed to a particular lexical class or lexical item. Within current Optimality Theory, this is little more than a stipulation. There is no principled reason why stratal indexation could not be extended to structural markedness constraints, resulting in special versions of, for example, NoCoda or No-P such as NoCoda/Foreign or No-P/Sino-Japanese, with their own special ranking.[61]

Replication of faithfulness constraints, and the nonreplicability of structural constraints, are of course not unique properties of the core–periphery model of the lexicon, but rather reflect a general feature of the correspondence model of Optimality Theory. The most important and influential case involves Base-Reduplicant (BR) faithfulness (McCarthy and Prince 1995, etc.), where the distinction between Faith-IO and Faith-BR has provided key insights into the workings of prosodic morphological phenomena.[62] For example, the ban against codas having tangible effects only in the reduplicant is accounted for by the "Emergence-of-the-Unmarked" schema in (54a) (McCarthy and Prince 1994a, 1995, Spaelti 1997, etc.), sandwiching the NoCoda constraint between the two faithfulness constraints. Non-replicability of structural constraints is important since the same effects could otherwise in principle be achieved by having an additional specialized NoCoda constraint applying only to the reduplicant (i.e. NoCoda/R), and sandwiching undifferentiated faithfulness between specialized and general NoCoda (54b).

(54) a. Faith-IO ≫ NoCoda ≫ Faith-BR
b. NoCoda/R ≫ Faith ≫ NoCoda

Codalessness in the reduplicant could then be due to either the EoU-schema (54a) or the alternative indexed account (54b), seriously undermining the explanatory level achieved by the theory. The issue here goes beyond redundancy: in unpublished work, Prince (1996) has given a cogent argument showing that templatic constraints such as NoCoda/R or R = MinWd, while not conceptually incompatible with the theory of reduplicative overapplication of McCarthy and Prince (1995), lead to empirically absurd results, such as reduplicating hypothetical *wakari* as *waka-waka* (instead of the expected *waka-wakari* or *wakari-kari*), with back-copying of the templatic property due to the ranking R = MinWd, Max-BR ≫ Max-IO. Extending the argument of Prince (1996), Spaelti (1997) demonstrates that theories operating with general templatic constraints such as Affix syllable (see McCarthy and Prince 1994b: 10, among others) suffer from the same back-copying problem, and goes on to develop a fully a-templatic model of reduplication (see also McCarthy and Prince 1998 for similar arguments). A templatic NoCoda/R constraint would fall to the

same criticism, as shown by the unattested back-copying of reduplicative codalessness into the base, as shown in (55).

(55)

| *Red + warum* | *No-Coda/R* | *Max-BR* | *Max-IO* | *NoCoda* |
|---|---|---|---|---|
| warum + warum | *! | | | ** |
| waru + warum | | m! | | * |
| ☞ waru + waru | | | m | |

That properties like codalessness are apparently never back-copied makes sense, if they are strictly due to the Emergence-of-the-Unmarked schema, which cannot coexist with the overcopying ranking for one and the same structural constraint. This in turn implies that the theory must not admit indexed structural constraint such as NoCoda/R.

From the analytical-empirical side, then, there is a need for faithfulness constraints to be indexable to various dimensions of grammatical derivation (such as truncation, reduplication, etc.) and also to strata in the lexicon. There is no such need for structural constraints – in fact, the opposite is suggested by the back-copying argument. Where does this prolific character of faithfulness constraints stem from, and why do structural constraints not share it? The answer should ideally come from the form and function of faithfulness constraints. Faithfulness is different from structural wellformedness in that faithfulness is always faithfulness *to* something, whereas NoCoda is not NoCoda to something. A candidate cannot be faithful *tout court*, in a way in which it has a coda or lacks an onset. Faithfulness constraints involve two linguistic representations and assess how similar one is to the other. In Correspondence Theory as developed in McCarthy and Prince (1995) and related work, faithfulness constraints are literally conceived of as constraints on a pair of corresponding representations. Taking up this proposal and developing it in a slightly different way, we start with a fundamental division between constraints that take a single representation as their argument (56a) and constraints that take two representations as their arguments (56b).

(56) a. *One-argument constraints:*
A given representation is judged in terms of its intrinsic harmony, irrespective of other representations. One-argument constraints are defined strictly on outputs (output candidates produced by Gen), and are the structural, wellformedness, and markedness constraints in the broadest sense, including segmental markedness constraints, sequential constraints, prosodic form constraints relating to syllables and feet, etc.

b. *Two-argument constraints:*
A given representation (an input or output representation, or a specific subpart of an output representation, such as a reduplicant) is judged by measuring it against a second representation (another input or output representation, or another part of the same output representation). These are the faithfulness constraints.

More formally, optimality-theoretic constraints can be thought of as devices that assign violation marks to representations (see Prince and Smolensky 1993: 68–71). Starting with a structural constraint *S*, *S* is a function that takes a candidate output representation *o* as its argument and assigns it a (possibly empty) list of violation marks for *S* as a value, as illustrated in (57).

(57) $S\ (o) = \textit{List of violations}$

e.g.:

| | |
|---|---|
| $S\ (o) = (\emptyset)$ | *o* is assigned no violation mark for constraint *S* |
| $S\ (o) = (*S)$ | *o* is assigned one violation mark for constraint *S* |
| $S\ (o) = (*S, *S)$ | *o* is assigned two violation marks for constraint *S*, etc. |

Some concrete examples are given in (58). The representation *.kaf.* is assigned a list consisting of one violation mark *NoCoda, and the representation *.kaf.tan.* is mapped to the list (*NoCoda, *NoCoda). The representation *.ka.ta.* consisting of two open syllables is assigned no violation mark by NoCoda (i.e. it is assigned the empty list as a value). The other examples follow the same pattern.

(58) a. NoCoda (*.kaf.*) = (*NoCoda)
NoCoda (*.kaf.tan.*) = (*NoCoda, *NoCoda)
NoCoda (*.ka.ta.*) = (ø)
b. No-DD (*.bed.do.*) = (*No-DD)
No-DD (*.bet.to.*) = (ø)
c. No-P (*.pan.*) = (*No-P)
No-P (*.han.*) = (ø)
d. No-NT (*.tom.po.*) = (*No-NT)
No-NT (*.tom.bo.*) = (ø)

Faithfulness constraints, on the other hand, require a different format, as shown in (59). Every faithfulness constraint *F* needs two arguments: besides a representation *o* to be judged, there is also a representation *i* serving as the model against which *o* is measured (*o* and *i*, even though mnemonic of "output" and "input," can also stand for subrepresentations of a single representation, such as reduplicant and base).

(59) $F\ (i)\ (o) = \textit{List-of-violations}$

Rewriting (59) in a form similar to (57), i.e. as a function of one argument returning a list of marks as value, we have (60b). What corresponds to the structural constraint *S* (60a) is not *F*, but rather the complex [*F*(*i*)].

(60) a. Structural constraint: $S(o)$ = *List-of-violations*
b. Faithfulness constraint: $[F(i)](o)$ = *List-of-violations*

This small change expresses a conceptual unification: just like structural constraints, faithfulness constraints are functions that are strictly defined on outputs. In a formal sense, this is a return to the original model of Optimality Theory in Prince and Smolensky (1993) in that all constraints apply to output representations. This version of Optimality Theory relied on the principle of containment (so named in McCarthy and Prince 1993b) in order to make phonological outputs rich enough for the computation of all faithfulness violations by requiring every output to *contain* the input. This model turned out to lack the degree of generality necessary to handle central aspects of phonology and prosodic morphology, such as the featural filling of epenthetic structure, reduplicant–base relations, etc., leading to the current correspondence-based conception. In the proposal made here, strict output-orientation for all constraints is made possible by enriching the internal structure of faithfulness constraints by correspondence, with a distinction between constraint schemata (F, e.g. MAX) and instantiated constraints (F(i), e.g. MAX (/kaftan/) in (61)). The new conception is illustrated in (61) for the constraint schemata MAX and IDENT, instantiated for the inputs /kaftan/ and /paN/.[63]

(61) a. [MAX (/kaftan/)] (kaftan) = (ø)
[MAX (/kaftan/)] (kafta) = (*MAX)
[MAX (/kaftan/)] (kata) = (*MAX, *MAX)
b. [IDENT (/paN/)] (paN) = (ø)
[IDENT (/paN/)] (haN) = (*IDENT)

In other words, MAX, DEP, IDENT, and other types of faithfulness are by themselves not constraints that could apply to an output candidate; rather, they are constraint schemata which, when applied to an input *i* related to an output candidate *o* by correspondence, yield (as its value) an *instantiated constraint F(i)*, which in turn applies to *o* to yield a list of violations of *F* by *o* relative to *i*. This entails that there is an instantiated faithfulness constraint for each lexical item. Instantiated faithfulness constraints are not elementary constraints, but rather derived within individual grammars by composing a universal constraint schema *F* with the elements of a lexical correspondence network. In the unmarked case, we assume that all instantiated constraints *F(i)* for a given constraint schema *F* occupy the same position in the ranking (notated in tableaux by the usual "MAX-IO," "DEP-IO," etc.). However, different from structural constraints, faithfulness constraints are by necessity specialized, with

a separate instantiation for each input item. This opens up the possibility of ranking different instantiated faithfulness constraints in different positions, and this formal option is exploited in lexical stratification – for various functional reasons that are not the concern of the cognitive system dealing with formal grammar. In stratification, this takes the form of indexed faithfulness constraints, as shown in (62). Here the instantiations of a given faithfulness constraint schema for items belonging to two different strata I and J are ranked differently with respect to some constraint C.

(62) $F(i) \gg C \gg F(j)$, where $i \in I$, $j \in J$, and $I$, $J$ are vocabulary strata.

For structural constraints the formal possibility of differential ranking simply does not arise because they do not have instantiations. Different from other approaches, this conception of faithfulness thus makes sense of the fundamental dichotomy between structural markedness and faithfulness, as far as indexability is concerned.[64]

## NOTES

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1 See S. E. Martin (1952), J. D. McCawley (1968b), Vance (1987), Shibatani (1990), Kubozono (1995c), among others.

2 We follow standard transcriptional practice, which is largely equivalent to the Hepburn style of Romanization used by the leading dictionaries, with some minor modifications. Thus for the palato-alveolar obstruent series, we use [š, č, ǰ], rather than {*sh*, *ch*, *j*}. For moraic nasal glides, we use [N] (i.e. if word-final or preceding a vowel or glide); and for assimilated nasals, [m, n, ŋ].

3 Shortened from *saunɴdo torakku*. For a phonological analysis of such shortenings, see Itô (1990) and Itô and Mester (1992).

4 Shortened from *patorooru kaa*.

5 Roughly speaking, *hiragana* and *kanji* are used for the native forms, *kanji* for the Sino-Japanese vocabulary, and *katakana* for the foreign vocabulary. For discussion of the writing system and its linguistic significance, see Miller (1967), S. Martin (1972), and references cited there.

6 For a detailed discussion of the phonological properties of mimetics, see Hamano (1986).

7 In fact, it is well known that the synchronic classifications, as evidenced by the overt behavior of speakers, in numerous cases

diverge from the true etymological origin of the items in question. Thus certain Yamato items, such as *fude* "brush" or *uma* "horse," are probably very early (and nowadays unrecognizable) borrowings from Chinese, mediated through Korean (see Sansom, 1928: 29–30). Even some older Western loans, like *tabako* "cigarettes, tobacco" and *karuta* "(playing) cards" (sixteenth-century, from Portuguese), are nowadays treated as native, and are written in *hiragana* and *kanji*.

8 For discussion, see e.g. Chomsky and Halle (1968: 174, 373), J. D. McCawley (1968b: 62–75), Postal (1968: 120–39), Saciuk (1969: 505–12).

9 See Itô and Mester (1995b) for examples, with references to the extensive literature on the topic.

10 See Mathesius (1929), among others.

11 C. C. Fries and Pike (1949) is an example.

12 See, for example, Holden (1976) and Lightner (1972) on Russian, and Nessly (1971) on English.

13 For further developments, see C. Paradis and Lebel (1994) on Quebec French, Cohn and McCarthy (1994) on Indonesian stress, Pater (1995) on English stress, Davidson and Noyer (1997) on Huave loan phonology, Kubozono (1997) on Japanese compound accent, Shinohara (1997) and Katayama (1998) on Japanese segment inventories and pitch accent, and Karvonen (1998) on Finnish loanwords.

14 Together with most researchers, we are assuming that the complex of conditions collectively referred to as the "Coda Condition" since Itô (1986) need further analysis. An approach that makes the required distinctions (i.e. disallowing non-place-linked codas while permitting geminates and place-assimilated nasals) is the alignment proposal in Itô and Mester (1994, 1998). In light of more recent work, a further reduction to a conjunction of more elementary factors is perhaps feasible – for example, to structural markedness locally conjoined with segmental markedness, as we have argued for coda-devoicing languages like German in other work (see Itô and Mester, 1997c: 130–2), building on Smolensky (1995). Related proposals have been made in Positional Faithfulness Theory, as in the work of J. N. Beckman (1998), Lombardi (to appear), Padgett (1995), and others.

15 Some of these forms have alternants without gemination (*oikakeru, oitsuku, oidasu*).

16 For further details regarding the gemination of other sonorant consonants, resulting in forms like *huɴwari* or *hiɴyari* (phonetically, [huw̃wari] and [hiỹyari]), see A. Mester and Itô (1989: 275).

17 Historically speaking, in forms nowadays pronounced with initial [h] some feature of labial articulation must have persisted until recent times. Thus in the early 1500s the future emperor Gonara is reported to have posed the following riddle:

(i) *haha ni wa ni-do aitare-do mo, čiči ni wa ići-do mo awazu*
"for mother (*haha*) they meet twice, for father (*čiči*) not even once"

The intended answer is *kučibiru* "(the) lips," which only makes sense if *haha* was still pronounced somewhat like [ɸaɸa]. S. E. Martin (1987: 11) comments: "It would seem that in the mainstream of the language, centering on the

capital cities, the syllable *ha* was pronounced *Fa* from as early as 800 till as late as 1600, at least initially."

18 See Poser (1984) for an illuminating discussion of double-verb compounding (10) and *ma*-prefixation (11), and see Itô and Mester (1996) and works cited there for many other examples of Sino-Japanese compounding (12).

19 For optimality-theoretic analyses of Sino-Japanese compounding, see Sakai (1994), Nasu (1996), and Kurisu (1998).

20 For further examples and discussion, see Itô and Mester (1986).

21 See Itô et al. (1995), Padgett (1995), Suzuki (1995), Pater (1996), and Hayes (1996) for different views regarding the constraints involved in the postnasal voicing syndrome. In order to sidestep unnecessary complications, we simplify the exposition of the analysis by means of the ad hoc constraint NO-NT. Similar remarks hold for NO-P and NO-DD, which can each be reduced to more elementary constraints.

22 See Davis and Tsujimura (1991) for an autosegmental analysis of the verbal alternations.

23 This root is felt to be archaic. Except for *šin-* "die," other *n*-final roots appear almost exclusively with stem-extensions in contemporary Japanese, e.g. *kasan-ar-u* "pile up," *sokon-er-u* "harm" for older †*kasan-u*, †*sokon-u*.

24 This form violates NO-P but obeys the sequential constraint disallowing the sequence *še* (or more generally, "palatal consonant + front mid vowel"). See Itô and Mester (1995a, 1995b) for further analysis and discussion of these sequential restrictions.

25 See the end of this section for some discussion of borderline cases.

26 See Itô and Mester (1995a, 1995b) and Tateishi (1989a) for details, and S. E. Martin (1952) and J. D. McCawley (1968b) for earlier comprehensive studies.

27 Cf. Saciuk's (1969) [–homogeneous] class.

28 See Itô and Mester (1995b: 830).

29 Cited in Rice (1997: 545). For other examples of contractions, see Itô and Mester (1995b: 837, n. 20) and references cited there.

30 These examples are discussed in Itô and Mester (1986: 54, 1995b: 830, 1997a: 427). Rice (1997: 554) adds further examples to this category.

31 Rice (1997) has critically argued against the approach advocated by Itô and Mester (1995a, 1995b) and Itô et al. (1995), basing her argumentation on the incorrect assumption that there are no alternations associated with the constraints that are involved in lexical stratification. Itô et al. (1998) show in detail that this criticism is invalid, cf. the alternations associated with NO-NT, NO-DD, and NO-P (see the examples in (8)–(15)).

32 See Prince and Smolensky (1993) as well as the large subsequent literature.

33 For a discussion of the limits on positing different "cophonologies" within the same grammar, see Inkelas et al. (1997).

34 We adopt here the correspondence-theoretic version of faithfulness, as developed by McCarthy and Prince (1995).

35 With respect to a more elaborate analysis differentiating between the various aspects of faithfulness, FAITH marks the position of the lowest-ranking relevant faithfulness constraint (MAX, DEP, etc.). See section 3.2 and the appendix for further discussion.

36 Top-ranked FAITH$_5$, which overrides even basic syllable constraints, appears to play no stratificatory role in Japanese, but see Itô and Mester (1995a: 198).

37 The indexed-FAITH format was first used by Pater (1995) for the English lexicon. Later applications include Prince (1996) and Fukazawa (1998) for Japanese. While the two versions of the theory are conceptually quite distinct, we are unaware of any decisive empirical differences between the two versions. As Rachel Walker (personal communication) has pointed out, hybrid formations, such as the cooccurrence of fixed affixes with alternating affixes in Tuyuca discussed and analyzed in R. Walker (1998: 116–38), are interesting in this regard: here simultaneous access to two rankings would be required (see also Fukazawa et al. 1998 for a case in Japanese) – a situation dealt with straightforwardly in the indexed faithfulness account, but calling for some imaginative development of the technical aspects of the original reranking proposal in Itô and Mester 1995a. Putting aside matters of execution and the technicalia of Correspondence Theory, the larger question for linguistic theory is whether variation *within* a single language is entirely different from – or related to – variation *between* languages, which must be the result of a difference in grammars, i.e. of differential constraint ranking.

38 Instead of FAITH/Yamato, it might be more adequate to make use of general, unindexed, IO-faithfulness. An indexed FAITH/Yamato family for core behavior is in danger of missing the point that core–periphery patterns show "Elsewhere" organization.

39 We are not concerned here with the quality of epenthetic vowels, which are mostly *u*, but *o* after coronal plosives where *u* would trigger major allophony (hence *beddo* instead of *beddzu*), and *i* after *k* in some older loans like *sutoraiki* "labor strike" (vs. *sutoraiku* "a strike in a baseball game").

40 The degeminating candidate [bedo] violates another higher-ranking constraint, either ALIGN-R (STEM, σ), requiring that the right edge of a stem and a syllable coincide (Kitahara 1996), or a sympathetic faithfulness constraint requiring the coronal /d/ to maintain its syllable role (here: as a coda, see Katayama (1998)).

41 See Prince and Smolensky (1993) and Itô et al. (1995) for further discussion.

42 Among early loans from Western languages, there are a few cases of *p*-replacement, such as the word *bateren* "padre" (modern *paadoru*) from Portuguese, and in some documents from the late Tokugawa period the last name of Commander Perry appears as *heruri*. But such cases are sporadic.

43 It is unsurprising that we find a considerable amount of variation in this area of the lexicon, with some speakers treating the loanword for "bed" as Assimilated foreign (i.e. *betto*), and the loanword for "bag" as Unassimilated foreign (i.e. *baggu*).

44 Further differentiation is of course possible and arguably required in terms of individual features, feature values, specification/underspecification, insertion/deletion, zero-, mono-, and bimoraicity, consonantal vs. vocalic moras, etc.

45 For the strata appearing in this model of the phonological

lexicon, the term "cophonologies" (see Inkelas et al. (1997)) is therefore misleading. Just as for reduplication and other areas where special faithfulness relations are involved, we are dealing with a single grammar and a single phonology.

46 Cf. Kiparsky's (1968) "hierarchy of foreignness," and see Itô and Mester (1995a: 191–2, 201–2) for other examples.

47 As given here, the argument from impossible nativizations rests on the simplifying assumption that all faithfulness constraints are, for purposes of stratal indexation, consolidated into a single monolithic "FAITH." Once property-specific faithfulness constraints are distinguished, such as IDENT-F and IDENT-μ in (23), further ranking options arise, such as IDENT-$\mu/_X \gg$ NO-DD $\gg$ NO-P $\gg$ IDENT-PLACE$/_X$, prima facie a way of deriving pseudo-nativizations like *habbu* at some stratum *X*. This loophole will be closed in section 3.2 by tightening the overall theory of constraint ranking.

48 A concrete proposal of this kind is advocated in Inkelas et al. (1997).

49 Or else the theory gives up altogether on characterizing the notion "possible nativization." Notice that pointing to the history of the language as holding the key to an explanation in this case amounts to a reversal of logic. Even though it is unpredictable whether, and when, some foreign item enters a language, the nativization course of an item, once acquired, is not at all arbitrary, but to a large extent determined by structural and markedness factors – precisely what we are trying to understand in the first place. There is thus no explanation of structure through history here; there is rather an explanation of (some aspects of) history through structure.

50 The example is modeled after the discussion of Turkish obstruent voicing in Inkelas et al. (1997: 408–10).

51 As in the work referred to, the tableau marks a violation of faithfulness for every [0anterior] segment acquiring a specification for [anterior] in the output. This is not a necessary assumption: Even if such feature filling were assumed not to violate faithfulness, the same winners would emerge – but the first column would contain one fewer asterisk in each cell.

52 Needless to say, in a general sense input specifications continue to remain central to the enterprise. Without input, no output will be derived, and marked segments, marked sequences, and marked structures will never emerge without being posited in the input. In this sense, there is no Optimality Theory without "prespecification." It is a different matter whether the "input" is best viewed as consisting of classical underlying representations or of surface representations of some kind, as suggested in some recent work (Flemming 1995, Ní Chiosáin and Padgett 1997, among others).

53 One could attempt to get around the problem by climbing up to some level of meta-markedness and assert that it is the unmarked state for a system to have all faithfulness constraints clustering together in the ranking (i.e. literally occupying, as a group, the rank informally marked as FAITH/X in our tableaux).

54 This version assumes that constraints are totally ordered (see Tesar and Smolensky 1998 for recent discussion). Under partial ordering, it is minimally necessary

to avoid ranking reversals: if $F/_A \gg G/_A$ for some stratum $A$, then there is no stratum $B$ such that $G/_B \gg F/_B$: $\neg\exists AB\ (F/_A \gg G/_A \wedge G/_B \gg F/_B)$. As formulated in (32), the IO-Ranking Consistency condition is a minimal condition, stronger versions are conceivable and perhaps justified. Thus one might consider strengthening it into a parallelism requirement (a reformulation along such lines appears in Fukazawa et al. 1998).

55 Going beyond IO-faithfulness constraints and their various stratally indexed incarnations, an important issue to consider is whether ranking consistency (32) can be generalized as in (i), linking IO-faithfulness to other dimensions of faithfulness in the grammar, such as base–reduplicant identity, output–output analogy, and opacity-inducing sympathy.

(i) *Generalized Ranking Consistency*: Let F and G be two types of faithfulness constraints (IDENT, MAX, etc.) and $A$ and $B$ types of correspondence (input–output, output–output, base–reduplicant, base–truncatum, etc.). Then the relative rankings of the indexed versions of F and G are the same across all faithfulness dimensions: $\forall AB\ (F/_A \gg G/_A) \Rightarrow (F/_B \gg G/_B)$.

Although it is conceivable that different dimensions of faithfulness will turn out to deviate from each other in such a way that (i) does not hold, it is difficult to construct a scenario in which, e.g. the IO- and BR-versions of a particular faithfulness constraint F are ranked differently with respect to a certain structural constraint M, and hence to each other. A prime example of exactly this type would seem to arise between IO-faithfulness and BR-faithfulness, when Emergence-of-the-Unmarked effects rely on the ranking $F/_{IO} \gg M \gg F/_{BR}$, for some faithfulness constraint F, and overapplication requires M, $G/_{BR} \gg G/_{IO}$ for some faithfulness constraint G. This does not constitute a ranking inconsistency in the sense of (i), since $F \neq G$. What is needed is a situation requiring $F/_{IO} \gg M \gg G/_{IO}$ in the IO-dimension and simultaneously $G/_{BR} \gg M \gg F/_{BR}$ in the BR-dimension. It is at present unknown whether an empirically convincing case can be made demonstrating that the faithfulness apparatus of Optimality Theory needs this kind of descriptive power. Until such cases are found, familiar considerations of restrictiveness recommend (i) as a general condition on faithfulness ranking.

56 Insofar as Ranking Consistency (32) governs the relation of the various versions of indexed IO-faithfulness constraints to each other, it recaptures the idea embodied in the earlier version of our theory (Itô and Mester 1995a), namely, that there is an underlying unity behind the various stratal incarnations of a given faithfulness constraint. This unity goes beyond their relatedness through the general schemata of Correspondence Theory (McCarthy and Prince 1995), which say nothing about the ranking of the pairs $F_A/G_A$ and $F_B/G_B$ in (32).

57 Smolensky (1996: 6–7) attributes the original proposal to Alan Prince.

58 In the case of Japanese, this result is facilitated by the rich system of alternations supported by the core grammar (see Itô et al. 1998 for discussion).

59 Here and in what follows, we make the simplifying assumption that the maximally "faithful" ranking

is always uniquely determined. For cases where ambiguities arise, a further refinement of the theory will be called for, which we leave for future development.

60 In order to admit such a mapping, a more radical revision of the grammar (or alternatively, a violation of Ranking Consistency) would be necessary, exacting a considerable cost.

61 Some analysts have indeed taken this step, which results in a less restrictive model of lexical stratification in which no consistent lexical subset structure, as in (16) and (17), is predicted to emerge. See Pater (1995) for an analysis of regular and exceptional secondary stress in English, where, alongside the faithfulness constraint StressIdent, the structural constraint StressWell ("No stressed syllable may be adjacent to the head syllable of the Prosodic Word") is indexed to a particular subset of the lexicon).

62 Others include Faith-BT (Base–Truncatum) for truncation processes (Benua 1995), Faith-BA (Base–Argot) for language games (Itô et al. 1996), level-specific faithfulness (level 1 vs. level 2 faithfulness for English (Benua 1997)), and surface analogy (Steriade 1997, Burzio 1997, Itô and Mester 1997a). Most recently, sympathetic faithfulness has been proposed by McCarthy (1997), and an analysis using sympathy has been proposed by Itô and Mester (1997b) for the Japanese *gagyō* alternation and by Katayama (1995, 1998) for recent loanwords in Japanese.

63 Cf. also Russell (1995) and Hammond (1997) for proposals that are in some respects similar to the one made here.

64 From this vantage point, the criticism raised in Benua (1997) against the faithfulness reranking model of Itô and Mester (1995a), while well taken, is seen not to go far enough. It is true that the theory does not provide an explanation for why only faithfulness constraints can be reranked – but the very same criticism can be leveled against standard Correspondence Theory, where the absence of NoCoda/R, etc. is simply a tacit assumption about the model, and does not follow from any more general principles. On the other hand, the proposal made here attempts an explanation by deriving replicability from the internal structure of constraints.

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