Chapter 7: Generative treatments of rendaku and related issues

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1. General introduction

This chapter provides an overview of how rendaku has been analyzed in the history of generative phonology, the mainstream framework of theoretical phonology. As we will observe, theoretical analyses of rendaku have been developed in tandem with the development of phonological theory. Therefore, rendaku has been analyzed within a theoretical framework that was dominant during that era. Concretely, the three major theoretical frameworks discussed in this chapter are: (i) the rule-based framework developed by Chomsky and Halle (1968) in their seminal book on generative phonology, *The Sound Pattern of English* (SPE), (ii) autosegmental phonology (Goldsmith 1976) coupled with underspecification theory (Kiparsky 1982), and (iii) Optimality Theory (OT: Prince and Smolensky 1993/2004), the currently most-dominant analytical framework. Although we will briefly explain the fundamental features of these theories, the readers are referred to other introductory textbooks for further details.

Roca and Johnson (1999) as well as Gussenhoven and Jakob (2011) offer a balanced introduction to both pre-OT theories and Optimality Theory (OT). Goldsmith (1990), Kenstowicz (1994), Roca (1994) and Spencer (1996) present a comprehensive coverage of pre-OT phonological theories, including Autosegmental Phonology, underspecification theory, and Lexical Phonology, which will be discussed in this chapter. Archangeli and Langendoen (1997), Kager (1999) and McCarthy (2002, 2008) offer an accessible introduction to OT. Rendaku and Lyman's Law are covered in some of the textbooks mentioned here (Gussenhoven and Jakob 2011: 58; Kenstowicz 1994: 493, 511-512; Roca 1994: 75-76; Spencer 1996: 60-61).

The organization of this chapter is as follows. We start with the theoretical analyses of rendaku itself—how rendaku voicing has been modeled—in section 2. Then we are going to discuss theoretical treatments of major factors that affect the application of rendaku. We first discuss how Lyman's Law has been treated in generative phonology in section 3; this section also deals with the issue of why Lyman's Law ignores voicing on sonorants. Section 4 turns to another restriction on rendaku, the so-called Right Branch Condition. Section 5 discusses other issues, including how theoretical phonology has dealt with the effect of lexical stratification on rendaku. The final section discusses remaining questions and offers some concluding remarks.

2. Theoretical treatments of rendaku

We will start with how the analyses of rendaku have been developed. We do so more or less in a chronological order, which allows us to track the development of theories of rendaku along with the development of phonological theory.

2.1. SPE-style rules

McCawley (1968), the first comprehensive generative treatment of Japanese phonology in general, briefly refers to rendaku (pp. 86-87). Although much of his book is formulated using SPE-style phonological rewrite rules (Chomsky and Halle 1968), for rendaku he suggests that he is "unable to state the environment in which the "voicing rule" applies" (footnote 18), where "the voicing rule" refers to rendaku. He seems to have been well aware of the lexical irregularity concerning rendaku, saying that "[t]he relevant data are completely bewildering" (footnote 18) (see Chapter xx), and does not provide its explicit formulation. He refers to Martin (1952) for factors that affect rendaku, but does not attempt to formalize them in the SPE framework that he adopts in other parts of the book.

Otsu (1980), using the quote from McCawley cited above as an epigraph, offers a more optimistic view in this regard and presents a more explicit formalization of rendaku (p. 217). His SPE-style rule is shown in (1):

(1) C(onsonant) => [+voice] / [$_N$ X[# __ Y
where (i) X ≠ null and
(ii) <u>Y</u> does not contain any voiced obstruents.

To put the rule in (1) in prose, it says that consonants become voiced, when they are preceded by a word boundary ("#"), which itself is preceded by an element ("X") and a noun boundary ("[$_N$") (see Otsu 1980 for full justification for positing this structural description). "Y" is included in the rule to encode the effect of Lyman's Law with the caveat (ii). The first caveat clause (i) says that this rule applies only to compounds, not word-initially. The second caveat (ii) encodes the effect of Lyman's Law. The rule in (1) is formulated as a phonological rule in the SPE format (Chomsky and Halle 1968), which was the standard formulation in phonological theorization until Autosegmental Phonology (Goldsmith 1976).

This rule may be, with hindsight, considered to be too descriptive: it is restating what is actually observed about rendaku, encoding many factors affecting rendaku application, including Lyman's Law, in one phonological rule. This descriptive-orientation was very common, however, in the early years of generative phonology (or generative linguistics in general). In later formalizations, rendaku is separated out from Lyman's Law, as we will see below.

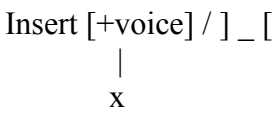
2.2. Autosegmental analysis

Ito and Mester (1986) develop a comprehensive analysis of rendaku and related issues within the framework of Autosegmental Phonology (Goldsmith 1976). In this theory,

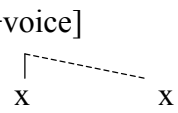
each distinctive feature behaves autonomously with respect to each other. Features can exist and behave independent of segments, and when they do so, they are called "floating features". Indeed, rendaku can be nicely treated as a floating [+voice] feature. The segmenthood in this theory is expressed by so-called "timing slots" also known as "a skeletal tier", represented in a various ways in different theories, including "x-slots" (Levin 1985), "C/V-slots" (Clements and Kayser 1983) or "root nodes" in Feature Geometry Theory (Sagey 1986; Selkirk 1990).

Within this framework of Autosegmental Phonology, Ito and Mester (1986) posit an autosegmental insertion rule of a [+voice] feature linked to an x-slot (p. 56) and a voicing spreading rule (p.58), which are reproduced here as (2) and (3). Note that in the voicing spread rule, a dashed line represents a new association line that is inserted by the rule at issue, a convention that is used in Autosegmental Phonology. As a result of this new association line, the initial segment of the second morpheme becomes [+voice].

(2) Rendaku: [+voice] insertion



(3) Voicing Spread



The [+voice] insertion rule more or less reflects the historical fact that rendaku originated as a result of reduction of the genitive marker /no/ to /n/, followed by post-nasal voicing or prenasalization (see Vance to appear; Chapter xx). The "x" slot to which [+voice] is associated in (2) mimics a timing slot of a compound marker (see also section 2.4), which is a historical residue of this genitive marker /no/. The Voice Spread rule in (3) mimics the historical effect of post-nasal voicing/prenasalization.

2.3. A special case of intervocalic voicing

Most theories of rendaku more or less treat rendaku as a language-particular, morphophonological rule. Soon after the birth of Optimality Theory (Prince and Smolensky 1993/2004), which attempts to do away with language-particular phonological devices (rules or constraints), Ito and Mester (1996) attempt to characterize rendaku as a special case of intervocalic voicing that occurs at a morpheme boundary.

Intervocalic voicing is a common phonological process that is observed in many languages (Kirchner 1996; Kaplan 2010), and in this regard, this proposal attempts to put rendaku on the same footing as many other languages. In the words of Ito and Mester (1996), "[r]endaku is not a language-specific constraint. Rather, in true OT-style, it is the

emergence of universal unmarkedness—in this case, of a member of the "Avoid Effort" family of constraints ruling out changes in glottal state (here, a switch from voicing to voicelessness back to voicing)" (p.12).

Intervocalic voicing is a phonetically motivated process (Kirchner 1996; Kaplan 2010) in the sense that it allows speakers to continue their glottal vibration in VCV sequences. In other words, it allows speaker to "avoid the effort" of stopping glottal vibration by abducting the glottis during a consonant interval between two segments for which glottal vibration is required. Ito and Mester's (1996) view is, in short, that rendaku is a morphophonologized version a phonetically-motivated phonological process. The environment in which it applies may be language-particular, but the process itself is what is commonly observed in other languages.

2.4. A compound marker via REALIZE MORPHEME constraint

Ito and Mester (2003a: 83-85) go back to the idea that is similar to Ito and Mester (1986) and capitalize on the similarity between rendaku and "compound boundary markers" or "linking morphemes" that appear in many other languages (see Chapter 12, and section 2.2; see also Akinlabi 1996, 2011 for lists of featural affixes in other languages). They thus assume, just like Ito and Mester (1986), that the linking morpheme consists of a [+voice] feature. In some languages, such markers are segmental, as in German "*fugen-s*", whereas in others, they are subsegmental (i.e. featural), as in the case of rendaku. In this view there are no substantial differences between segmental morphemes and subsegmental morphemes.

Instead of the spreading rule shown in (3), Ito and Mester (2003a) argue that rendaku occurs when a constraint that requires phonological realization of a morpheme is effective. The particular constraint that they deploy is REALIZE-MORPHEME (REALIZE-M), and Kurisu (2001) shows that this constraint is motivated in many different languages by causing many phonological changes to signal the presence of a morpheme. (The particular rendition of REALIZE-M that Ito and Mester (2003a) use is actually different from Kurisu's formulation, and indeed is equivalent to $\text{MAX}_{\text{Subseg}}$[voice] proposed by Zoll (1996), which requires a floating [+voice] feature to be realized).

This constraint requires that the [+voice] feature associated with the compound marker be phonologically realized. To the extent that REALIZE-M is a universal constraint, as Kurisu (2002) and others claim, rendaku can be characterized as a manifestation of this universal constraint, without resorting to the idea that rendaku is a special case of intervocalic voicing, as in Ito and Mester (1996).

Section 3.4 presents an Optimality Theoretic implementation of how REALIZE-M works, together with a constraint that is responsible for Lyman's Law. At this point, it suffices to understand that the rendaku-as-a-compound-marker view has its incarnation in Optimality Theory, which capitalizes on the universality of phonological processes.

2.5. Rendaku as (lack of) devoicing

All the analyses above assume that when rendaku occurs, morpheme-initial consonants are underlyingly voiceless, and get voiced when they undergo rendaku; i.e. rendaku is a voicing process. Kuroda (1963, 2002) takes a different approach—he posits that the rendaku-undergoing consonants are in fact underlyingly voiced, and they get devoiced when they appear word-initially. In this view, those that look to be "voiced" undergo no phonological changes, and it is instead word-initial consonants that undergo devoicing. This analysis relates itself to the fact that Old Japanese did not allow word-initial voiced obstruents (Kuroda 2002: 341; Martin 1987: 29-30; Takayama to appear; Unger 1975: 8). As Kuroda himself admits (2002: 341), this idea is "radical", and to the best of our knowledge, has not been pursued in depth by anybody but Kuroda.

A challenge to this analysis is the fact that contemporary Japanese do have some words that begin with voiced obstruents, even within native words (e.g. /doo/ どう 'how'; /der-u/ 出る 'to get out'; /damas-u/ だます 'deceive': Ito and Mester 2003a: 32-33), and therefore this analysis has to deal with why these exceptional words are allowed. Of course a similar challenge applies to the rendaku-as-a-voicing-rule analysis as well, in that not all voiceless segments are voiced in the rendaku-environment. See section 5.2 for further discussion on this point.

2.6 Summary

In summary, rendaku has been treated in various ways in a number of different theoretical frameworks. One clear trend is that in earlier work (McCawley 1968; Otsu 1980; Ito and Mester 1986), rendaku was captured as a language specific rule. After the advent of Optimality Theory (Prince and Smolensky 1993/2004), which emphasizes the role of universality in phonological theorization, attempts have been made to characterize rendaku in terms of otherwise independently motivated phonological principles. Rendaku was thus tied to intervocalic voicing by Ito and Mester (1986) and to a morpheme realization requirement by Ito and Mester (2003a).

3. Theoretical expressions of Lyman's Law

As we observed in section 2, there have been various attempts to characterize rendaku from the viewpoint of generative phonology. Equally important in the theoretical development of rendaku analyses is the treatment of Lyman's Law—the blockage of rendaku by a voiced obstruent in the second element of a compound (see Chapter xx for details). Recall from the rule in (1) that Otsu (1980) encodes Lyman's Law in the formulation of rendaku (the clause (ii) in (1)). Later theories attempt to derive Lyman's Law from independently motivated phonological principles.

We discuss several theoretical implementations of Lyman's Law first, setting aside the issue of why Lyman's Law ignores the [+voice] feature in sonorants. After reviewing several theoretical incarnations of Lyman's Law, we will come back to this general issue in section 3.5. In the final subsection, we will discuss how Lyman's Law interacts with another phonological process in Japanese, velar nasalization, which results in so-called opacity.

3.1. Lyman's Law as an autosegmental feature deletion rule

Ito and Mester first characterize Lyman's Law as an autosegmental deletion rule (p.60, their (26)), which is reproduced below as (4):

(4) Lyman's Law in Ito and Mester (1986)[1]

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[+voice]=> Ø / _ [+voice]
                     |
                     x'
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This rule deletes the rendaku [+voice] feature when followed by another [+voice] feature.

3.2. OCP(voice)

Ito and Mester (1986: Appendix II) go beyond the language-particular formulation of Lyman's Law in (4), and attempt to characterize Lyman's Law in terms of a more general phonological mechanism. Concretely, Ito and Mester (1986) propose to derive Lyman's Law from a more general principle in phonology, namely, the Obligatory Contour Principle (OCP).[2] OCP (Leben 1973; Goldsmith 1976; McCarthy 1986 *et seq.*) is a principle that prohibits adjacent identical features, and is intended to account for the cross-linguistic observation that languages avoid similar segments in proximity.[3] In many

[1] "x' (x-prime)" here means "stray" or unsyllabified. See section 4.2 for why this formulation is useful. See also Ito and Mester (1986) for the full justification.

[2] To what extent OCP(voice) is a universal principle remains debatable, however. In fact, dissimilation in voicing is cross-linguistically very rare, and usually historically arose from dissimilation of other features, such as aspiration (Ohala 1981, 1993); for the case of Japanese, it was dissimilation in a prenasalization contrast in Old Japanese (Unger 1975; Vance 2005). Building on Ohala (1981, 1993), Kawahara (2008) argues that OCP(voice) is actually neither universal nor innate, and it has to be learned on a language-by-language basis, based on positive evidence in the learning data. Data from actual language acquisition patterns would bear on this debate in important ways. For the patterns of acquisition of rendaku in L1 and L2, see Chapter xx.

[3] OCP was first proposed for tonal features by Leben (1973), and hence assumed its name ("Contour"). OCP is extended for non-tonal segmental features by several subsequent works (Ito and Mester 1986; McCarthy 1986; Mester 1986). Ito and Mester's (1986) work was instrumental in the development of Autosegmental Phonology in showing that

languages, indeed, similar segments are avoided by way of dissimilation (Suzuki 1998:152-158 for a list of examples). Ito and Mester (1986) thus propose that Lyman's Law is an instance of OCP, more specifically, OCP(voice). The blockage of rendaku due to Lyman's Law is, in a sense, dissimilation, or blockage of creating a configuration that would otherwise be avoided by dissimilation.

OCP(voice) was also tied to the observation that native morphemes rarely or never contain two voiced obstruents (/fuda/ 'amulet', /buta/ 'pig', but no */buda/: Ito and Mester 2003a 35-36; Suzuki 1998: 12), and was thus proposed to function as a Morpheme Structure Condition (MSC: Stanley 1967) on the Japanese lexicon (Ito and Mester 1986:67-68). In this view, then, OCP(voice) applies both on underlying representations and on derivational processes (McCarthy 1986). See section 5.1.2 for further implications of this observation about the dual nature of Lyman's Law.

3.3. Local conjunction

Alderete (1997) argues that dissimilation targets not only segmental features, but also structures which are not commonly expressed with distinctive features, such as long vowels, geminates, or complex segments; e.g. long vowels and geminates are usually not expressed in terms of [+long] (Chomsky and Halle 1968), but instead a segment linked to two timing slots (see the references cited in section 2.2). Alderete (1997) proposes that what is crucial to dissimilation is that what gets simplified via dissimilation is a structure that is *marked*, the notion that became central in Optimality Theory (Prince and Smolensky 1993/2004).

To formalize this idea, Alderete (1997) argues that dissimilative effects should be derived via self-local conjunction of a markedness constraint $\{*M\&*M\}_D$, using the theory of local conjunction (Smolensky 1993, 1995, 1997).[4] A self-conjoined constraint is violated for each domain which includes two instances of a structure that is penalized by *M. According to this theory, Lyman's Law is $\{*[+voice, -son]\&*[+voice, -son]\}_{Stem}$

[+voice] can behave as a floating, autosegemental feature, and that [+voice] can be subject to a phonological principle like OCP. This is a showcase example of a recurrent theme in Ito and Mester's works in general: they deploy independently proposed phonological mechanisms to an apparently language-specific process like rendaku. See section 5.3 for more on this general point.

[4] The general idea of local conjunction was first proposed and developed by Paul Smolensky as a means to explicate the internal structure of the universal constraint set CON in Universal Grammar, assumed in Optimality Theory (Smolensky 1993, 1995, 1997). It was later extended as a means to create a new constraint based on two independently motivated constraints (Fukazawa and Lombardi 2003). See McCarthy (2002: 43) for further discussion and references on local conjunction. Self-conjunction was already pursued by the original work by Smolensky (1995: 4). Zamma and Kikuchi (to appear) argue that self-conjunction may require additional stipulations about constraint violation computation, compared to normal conjunction of constraints.

(Alderete 1997: 20-23). This local-conjunction based analysis of Lyman's Law is further developed in Ito and Mester (1996, 2003a).

3.4. An interlude: A fully OT analysis

By way of summary of (some of) the discussion so far, a full OT-analysis developed by a series of work by Alderete (1997) and Ito and Mester (1996, 2003a, 2008) is reproduced in this section. Their analyses make use of the constraint set shown in (5) (where "D" is used to stand for "voiced obstruents in general").

(5) The definition of the constraints

a. NO-D^2_m: No two voiced obstruents within a morpheme.
b. REALIZE-M: The input rendaku morpheme [+voice] should have phonological exponent.
c. IDENT(VOI): A segment must have the same specification for [voice] between inputs and outputs.
d. NO-D: No voiced obstruents.

The first constraint is, as reviewed above, a theoretical expression of Lyman's Law. Recall that Ito and Mester (2003a) posit a [+voice] feature as a compound marker, and the constraint in (5b) requires this morpheme to be realized in the output. (5c) is a faithfulness constraint which militates against featural change between the input and the output. The constraint (5d) is not active (in any obvious ways) in contemporary Japanese, but is posited based on a cross-linguistic motivation that voiced obstruents are marked (Hayes and Steriade 2004; Kawahara 2006).

The constraint ranking is given in (6) (adopted from Ito and Mester 2003a: 96, their (38)):

(6) The OT-constraint ranking

NO-D^2_m
| "Lyman's Law blocks rendaku"
REALIZE-M
| "Rendaku changes underlying voicing specification"
IDENT(VOI)
| "Obstruent voicing is contrastive"
NO-D

These analyses are illustrated in the following tableaux (their (39) with slight modifications). Portions that show crucial ranking arguments are shown in bold. "R" represents a linking [+voice] morpheme.

(7)

(a) NO-D^2_M >> RELAIZE-M blocks rendaku

/naga+R+sode/	NO-D^2_m	REALIZE-M	IDENT(VOI)	NO-D
naga zode	*!		*	***
=> naga sode		*		**

(b) RELAIZE-M >> IDENT(VOI) causes rendaku

/natsu+R+sora/	NO-D^2_m	REALIZE-M	IDENT(VOI)	NO-D
=> natsu zora			*	*
natsu sora		*!		

(c) IDENT(VOI) >> NO-D protects voicing contrasts in other environments

/aza/	NO-D^2_m	REALIZE-M	IDENT(VOI)	NO-D
=> aza				*
asa			*!	

As shown in the tableau (7a), the ranking NO-D^2_M >> RELAIZE-M blocks rendaku, as per Lyman's Law. When Lyman's Law is not relevant, rendaku applies, as in (7b), in response to the pressure of REALIZE-M. The ranking IDENT(VOI) >> NO-D guarantees that voicing is contrastive in non-rendaku environments in Japanese phonology.

3.5. Why sonorant voicing is ignored by Lyman's Law

One important issue that has been repeatedly discussed in the theoretical literature is why sonorant voicing is ignored in the calculation of Lyman's Law in Japanese (as assumed in the tableau in (7b) above). It is only voicing on obstruents that blocks rendaku, and voicing on sonorants seem to be ignored in this regard. If it were not, then rendaku would have been blocked even by a vowel, and rendaku would not occur in any environments.

3.5.1. Underspecification

To answer this question of why sonorant voicing is phonologically inert, Ito and Mester (1986) built on the then-dominant theory of underspecification (Archangeli 1988; Kiparsky 1982), in which redundant or predictable feature specifications are underspecified in (some phases of) phonological derivation.[5] Since [voice] is not

[5] There are/were two major versions of underspecification theory: contrastive underspecification in which only non-contrastive features are underspecified (Steriade 1987), and radical underspecifition in which non-contrastive features as well as default/unmarked features are underspecified (Archangeli 1988; Kiparsky 1982) (see Steriade 1995: 124-147 for an overview). Here it suffices to understand that sonorants were proposed to be underspecified for voicing specifications in Japanese phonology and other languages (again, see Steriade 1995: 115-116). Ito and Mester (1986) use radical underspecification, whereas Mester and Ito (1989) use contrastive underspecification. Since this debate is not crucial to our current understanding of rendaku and Lyman's Law,

contrastive on sonorants in Japanese (and many other languages), sonorant consonants are not specified for [voice], and hence Lyman's Law only looks at [voice] on obstruents.

We note in passing that this phonological "inertness" of voicing on sonorants is not uncommon cross-linguistically; a famous case is voicing of sonorants in Russian, which is phonologically inert in voicing assimilation (e.g. Hayes 1984). The underspecification of [voice] on sonorants therefore seems to be motivated on cross-linguistic grounds.

3.5.2. Privative feature theory

Mester and Ito (1989: 277-279) on the other hand argue that [voice] is a non-binary, privative feature that is specified for only obstruents throughout the phonological derivation (see also Cho 1990; Lombardi 1991; Steriade 1987; 1995: 147-157 for a similar view). In this view, there are no [-voice] features. Voiceless obstruents are therefore unspecified for voicing, instead of having [-voice] feature.[6] Since sonorants do not bear [voice] feature at all, Lyman's Law can look at obstruent voicing only.

3.5.3. Obstruent voicing and sonorant voicing as different features

Both of the explanations proposed by Ito and Mester (1986) and Mester and Ito (1989) assume that voicing in sonorants in Japanese is phonologically inert. Rice (1993) on the other hand argues that Japanese sonorants do need to bear [+voice] feature, because Japanese nasals trigger post-nasal voicing in the past tense formation (e.g. /sin-**t**a/ => [sin-**d**a] 死んだ 'died') (see also Ito, Mester, Padgett 1995 for discussion on this apparent paradox). Rice (1993) therefore proposes that sonorant voicing and obstruent voicing are different features.

A general idea behind this theory is that whereas voicing in sonorants occurs spontaneously (Chomsky and Halle 1968), voicing in obstruents requires some articulatory maneuvers in order to deal with the aerodynamic challenge that voiced obstruents present (Hayes and Steriade 2004; Kawahara 2006; Ohala 1983). Therefore, some theories of voicing posit two voicing features: [S(pontaneous)V(oicing)] for sonorants and [L(aryngeal)V(oicing)] for obstruents (Avery and Idsardi 2001; Rice and Avery 1989). Rice (1993) argues that it is [LV] that Lyman's Law targets, whereas post-nasal voicing occurs as an assimilation process of [SV].

3.5.4. Direct encoding in constraint formulation

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their arguments are not reproduced here. Mester and Ito (1989: 259-267) provide an accessible summary of the comparison between the two underspecification theories.

[6] Voiceless sonorants are treated as aspirated sonorants (Lombardi 1991: Chapter 4; Mester and Ito 1989: 279). Apparent assimilation in terms of voicelessness in obstruent clusters is accounted for by the combination of neutralization and spreading (Lombardi 1991: Chapter 2).

With the shift from rule-based phonology to constraint-based theory (Optimality Theory: Prince and Smolensky 1993/2004), the more explanatory burden is placed on constraint formulation than on representational assumptions. Within this framework, to formulate Lyman's Law, Kawahara (2006), instead of relying on any of the representational assumptions reviewed above, or local conjunction, simply formulates Lyman's Law as a rendition of OCP against two voiced obstruents; namely, OCP([+voice, -son]).[7] See Alderete (1997), and Ito and Mester (1996, 2003a) for related ideas based on local conjunction.

3.5.5. Lyman's Law as orthotactics

Backing up from all the theoretical analyses described above, from a non-linguistic point of view, there may be a very straightforward characterization of Lyman's Law in terms of Japanese kana-orthography. As reviewed in Chapter 1, Japanese orthography marks voicing on obstruents with a diacritic (*dakuten*: 濁点), but not on sonorants. Therefore, Lyman's Law can be understood as a prohibition against two *dakuten* diacritics.

Fukazawa et al. (2013) and Kawahara (2014) entertain this hypothesis, independent of rendaku. Fukazawa et al. (2013) analyze the patterns of geminate devoicing in loanwords. Geminates devoice (optionally) when they co-occur with a voiced obstruent (e.g. /**d**o**gg**u/ => /**d**o**kk**u/ 'dog') (Nishimura 2003 *et seq*), and this devoicing can be understood as an effect of Lyman's Law. Moreover, /p/ seems to cause devoicing of geminates as well (e.g. /**p**irami**dd**o/ => /**p**irami**tt**o/ 'pyramid'). This observation raises the possibility that this devoicing occurs because /p/ also has a diacritic mark (*han-dakuten*; 半濁点). It is then very straightforward to say that Lyman's Law prohibits two diacritics within a morpheme.

This view treats Lyman's Law as orthotactic, a restriction on letter configurations (Bailey and Hahn 2001) rather than on sound configurations. Lyman's Law is OCP(diacritic) rather than OCP(voice). This view naturally explains why sonorant voicing is ignored in the computation of Lyman's Law as well, because sonorant voicing is not marked by *dakuten* in Japanese orthography. Note also that rendaku is more transparent when viewed from an orthographic point of view than from a phonetic point of view (Chapter 1). As discussed in Chapter 1, then, this orthotactic theory of Lyman's Law makes a testable prediction that those children who have not learned the Japanese orthography system will not show the effect of Lyman's Law.

3.5.6. Summary

One prominent theme in the theorization of Lyman's Law has been to address why sonorant voicing is systematically ignored. Various theoretical proposals, which have been proposed on independent grounds, have been deployed: underspecification,

[7] Kawahara (2006) does not discuss rendaku *per se*, but analyzes devoicing of geminates due to Lyman's Law that is found in loanwords (Nishimura 2003, 2006 *et seq*). See section 3.5.5 for more discussion on this devoicing pattern.

privative features, and an obstruent-specific voicing feature. A less theory-oriented, orthography-based explanation is also not negligible.

3.6. Lyman's Law and velar nasalization: derivational opacity

We finish the discussion on Lyman's Law by addressing how it interacts with another phonological process of Japanese. The blockage of rendaku by Lyman's Law is rendered opaque by another phonological process in Japanese, namely, intervocalic nasalization of [g] (Ito and Mester 2003b). In some dialects of Japanese, [g] becomes nasalized and becomes [ŋ] (Ito and Mester 1997a; Vance 1987). This segment [ŋ] is not a voiced obstruent, but it still blocks rendaku, as in [saka-toŋe] 'reverse thorn'.

This interaction is opaque in the sense that the surface [ŋ] acts as if it is a voiced obstruent in that it triggers Lyman's Law, although its surface realization is a sonorant. In other words, the blockage of rendaku due to Lyman's Law overapplies and rendaku underapplies,[8] despite the application of velar nasalization. This situation is called "opacity", because it is not clear only from the surface representations alone why Lyman's Law fails to apply.

In a derivational theory of phonology, if rendaku (and its blockage) precedes velar nasalization, this opacity is explained. Illustrative derivations are shown in (8):

(8) Illustrative correct and incorrect derivations

The right ordering		The wrong ordering	
UR	/saka+toge/	UR	/saka+toge/
rendaku	blocked by LL	velar nasalization	/saka+toŋe/
velar nasalization	/saka+toŋe/	rendaku	/saka+doŋe/
SR	[saka+toŋe]	SR	*[saka+doŋe]

This rule order (rendaku => velar nasalization) is also supported by the fact that [g] that is created by rendaku is fed to velar nasalization rule and becomes [ŋ] (e.g. /koku+ŋai/ 国外 'abroad'; see Chapter 1 and Ito and Mester 1997a).

Ito and Mester (2003b) develop an OT-equivalent of this derivational analysis, incorporating the distinction between lexical phonology and post-lexical phonology

[8] See Benua (1997) for the two terms (overapplication and underapplication), as they relate to phonological opacity. The two terms are originally due to Wilbur (1973) as they apply to reduplication, and became widely used again because of influential work by McCarthy and Prince (1995). The classical reference on phonological opacity is Kiparsky (1973). For further references on rule ordering, opacity, and the combination of Lexical Phonology with OT, see McCarthy (2002: 62, 184, 185).

(Kiparsky 1982) back into Optimality Theory. See Ito and Mester (1997b) for an analysis based on Sympathy Theory (McCarthy 1999), and Ito and Mester (2003b) for criticisms of the Sympathy-based analysis.

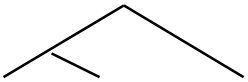
4. The Right Branch Condition

In addition to the issue of how rendaku itself and Lyman's Law should be analyzed theoretically, another aspect of rendaku that has received theoretical attention is the Right Branch Condition (Otsu 1980:219), which is restated in (9).[9]

(9) Rendaku applies only when a potential rendaku segment is a right branch constituent.

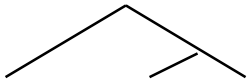
Right Branch Condition is intended to account for a difference between a pair like the following one (this minimal pair is attributed to Susumu Kuno by Otsu 1980:223):

(10) (i)



nise + **d**anuki + **j**iru
'[[fake raccoon] soup]'

(ii)



nise + **t**anuki + **j**iru
'[fake [raccoon soup]]'

where elements on a right branch of compounds get voiced (10-i), but not elements on a left branch (10-ii).

4.1. c-commanding requirement

Otsu (1980: 220-221) argues that an element that c-commands N1 (=X in (1)) undergoes rendaku, given the definition of c-command in (11):

(11) Definition of c-command
Node A c-commands node B if neither A nor B dominates the other and the first branching node which dominates A dominates B (adopted from Otsu 1980: 220, itself based on Reinhart 1976: 32).

or more plainly put:

(12) Go one node up higher in the tree and go down from there (but do not come back).

[9] Whether the Right Branch Condition is psychologically real or not has been debated in various experimental works (Ihara and Murata 2006; Kozman 1998; Kumagai 1999). See also Vance (1980) and Kubozono (2005) for criticisms on Right Branch Condition. See Chapter 8 for details of this debate. The analyses reviewed in this section assume that Right Branch Condition is true and psychologically real.

In (10-i), /tanuki/ c-commands /nise/, so it undergoes rendaku; at the next morphological concatenation, /siru/ c-commands /nise-danuki/, and it also undergoes rendaku. In (10-ii) on the other hand, /siru/ c-commands /tanuki/, so it undergoes rendaku; however, /tanuki/ does not c-command /nise/, and hence it does not undergo rendaku. If this argument goes through, then it shows that the same principle—c-command—may play an important role in syntax, semantics, and phonology.

4.2. A cyclic analysis

Ito and Mester (1986) start out with a concern about the theoretical expressiveness of Right Branch Condition, as formulated in (9). In many phonological theories, in morphological derivation, after each morphological concatenation or cycle, the internal structure should be erased (a.k.a. Bracket Erasure: Chomsky and Halle 1968:20; Kiparsky 1982:140; Pesetsky 1979: 44). A typical formulation is given below in (13) (taken from Pesetsky 1979: 44), and this principle is assumed in many theories of phonology.

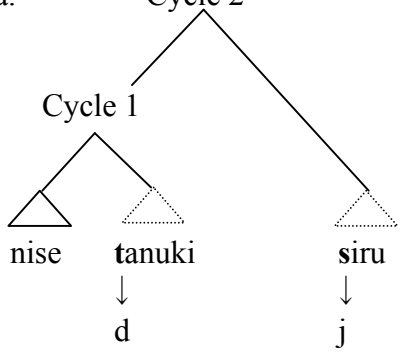
(13) Bracket erasure (Pesetsky 1979: 44)

Given the nested constituents
$[_n \ldots [_{n-1} \ldots \ldots_{n-1}] \ldots _n]$
the last rule of the cycle n is: Erase brackets n-1

Assuming the Bracket Erasure Convention, the information such as "right branch" should not be visible to phonological operations. Moreover, inclusion of a syntactic principle like c-command in a phonological rule was of some concern.

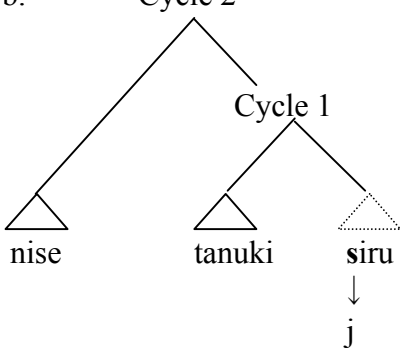
They instead proposed that cyclic concatenation of morphemes naturally explains the effect of Right Branch Condition. Consider (14) (taken from Ito and Mester 1986:63, their (30)):

(14) a.



'[fake raccoon] soup'

b.

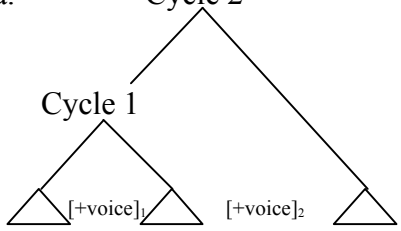


'fake [raccoon soup]'

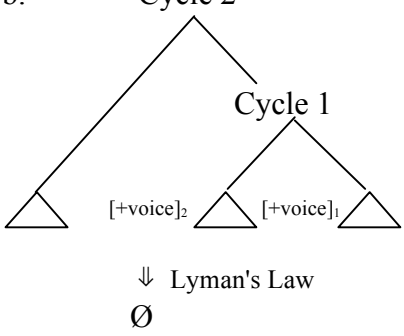
In the right branching compound shown in (b), /tanuki/ and /siru/ is combined first at Cycle 1, and rendaku occurs on /siru/. In Cycle 2, /nise/ is combined with /tanuki+jiru/, and rendaku is blocked here, because the second element already contains a [+voice] feature on [j]. In the left branching compound shown in (a), in Cycle 1, /nise/ and /tanuki/

are concatenated first, and rendaku applies, yielding /nise-danuki/. In Cycle 2, /nise-danuki/ is combined with /siru/ and rendaku applies, as /siru/ does not contain [+voice] feature. Their more general idea is illustrated in (15) (Ito and Mester's (31)).

(15) a.



b.



The gist of the idea is that in a right-branching compound, rendaku is blocked in the second element, because [+voice] is already inserted in Cycle 1 in E2 (the left figure). Importantly, it should not matter whether the [+voice] feature is segmentally realized or not, because rendaku needs to be blocked in examples like /nuri+/hasi+ire//, where [+voice] in the third element is not realized. A floating [+voice] (V_1) should suffice to trigger Lyman's Law to delete V_2.

Otsu (1980:218-219) indeed entertains this cyclic analysis, but rejects it perhaps because at that time in 1980, the notion of "floating feature" was not that common; without deploying floating features, in examples like /nuri+/hasi+ire//, rendaku on /hasi/ cannot be blocked, because /ire/ does not realize with [+voice] feature. Autosegmental Phonology allowed a feature to be active without being realized segmentally, and made the cyclic analysis of Right Branch Condition possible.

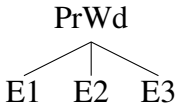
4.3. Positional faithfulness at PrWd edge

In Optimality Theory, it is common to do away with cyclic derivations, either phonological or morphological (Benua 1997). In this spirit, Ito and Mester (2003a) proposed a non-derivational analysis of Right Branch Condition. In particular, they proposed two different prosodic structures for right-branching compounds and left-branching compounds as (16) (pp.207-208). The structure posited in (16b) is based on independent observation that right-branching compounds are often groped into two accentual groups (Kubozono 1993).[10]

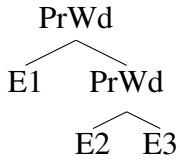
[10] In more recent work (e.g. Ito and Mester 2007), left-braching compounds too receive a recursive parsing, but in a way that E2 does not stand Prosodic-Word-initially; i.e. $\{_{\text{PrWd}}$ $\{_{\text{PrWd}}$ E1 E2$\}$ E3$\}$. This detail does not affect the discussion that follows here.

(16)

(a) Left-branching compound



(b) Right-branching compound



Building on the two different representations in (16), they argue that E2 in (b) are located at an initial position of a Prosodic Word, and that it is protected by a special positional faithfulness constraint that protects the voicing value of segments that stand in the initial position of a Prosodic Word (Beckman 1998). This analysis is illustrated in the tableaux below (pp.207-208):

(17)

(a) Rendaku applies on a left-branching compound

//nise+R+tanuki/+R+shiru/	IDENT(VOI)$_{PR\_INI}$	REALIZE-M	IDENT(VOI)
=> {$_{PrWd}$ nise+danuki+jiru}			**
{$_{PrWd}$ nise+tanuki+jiru}		*!	

(b) Rendaku is blocked in a right-branching compound

/nise+R+/tanuki+R+shiru//	IDENT(VOI)$_{PR\_INI}$	REALIZE-M	IDENT(VOI)
{$_{PrWd}$ nise{$_{PrWd}$danuki+jiru}}	*!		**
=>{$_{PrWd}$ nise{$_{PrWd}$tanuki+jiru}}		*	

5. Other issues and general discussion

Before closing this chapter, this section covers issues related to rendaku beyond Lyman's Law and Right Branch Condition. Some of the issues have been extensively discussed in the literature, some of them less so.

5.1. Other issues

5.1.1. Rendaku and lexical stratification in Japanese

One issue that did not fit in the discussion above, which is nevertheless important, is the fact that rendaku applies mostly to native words, and not to foreign words (Chapter 4). This nature of rendaku was taken as a piece of evidence that the Japanese phonological lexicon is stratified according to quasi-etymological features, most famously in a core-periphery model developed by Ito and Mester (1995a,b, 1999, 2003a, 2008) (though see Kuroda 2002, Rice 1997, Tateishi 2003 for skepticisms of this view). Ito and Mester (1995b, 1999, 2003a, 2008) model the blockage of rendaku in foreign items by positing faithfulness constraints that are specific to foreign items and to Sino-Japanese items.

Their analyses are illustrated below (adopted from Ito and Mester 2003a:148 with slight modifications).[11]

(18)

(a) IDENT(VOI)$_F$ >> REALIZE-M blocks rendaku in foreign words

/kankoo+R+takusii$_f$/	IDENT(VOI)$_F$	IDENT(VOI)$_{SJ}$	REALIZE-M	IDENT(VOI)
kankoo+dakusii	*!			*
=> kankoo+takusii			*	

(b) IDENT(VOI)$_{SJ}$ >> REALIZE-M blocks rendaku in Sino-Japanese words

/kari+R+keeyaku$_{SJ}$/	IDENT(VOI)$_F$	IDENT(VOI)$_{SJ}$	REALIZE-M	IDENT(VOI)
kari+geeyaku		*!		*
=> kari+keeyaku			*	

(c) REALIZE-M >> IDENT(VOI) triggers rendaku in native words

/kisetu+R+tayori/	IDENT(VOI)$_F$	IDENT(VOI)$_{SJ}$	REALIZE-M	IDENT(VOI)
=> kisetu+dayori				*
kisetu+tayori			*!	

Their analysis, going beyond the specific case of Japanese, bear on the general theory of how to treat exceptions; within the context of Optimality Theory, there is a general debate about whether we should posit lexical-specific faithfulness constraints (Ito and Mester 1995b, 1999, 2003a, 2008), lexical-specific markedness constraints (Flack 2007; Pater 2000, 2010; Ota 2004), or even both (Inkelas and Zoll 2005, 2007). See Ito and Mester (2008: 92-94) for recent discussion on this general debate from the perspective of Japanese phonology.[12]

5.1.2. Lyman's Law, conspiracy and the duplication problem

Another important aspect in which rendaku, or more technically speaking Lyman's Law, has contributed to the development of phonological theory is its dual—or tripartite—nature. Recall from section 3.2 that Lyman's Law functions as a Morpheme Structure Condition in the sense that there are no or few Yamato morphemes that contain two voiced obstruents. Lyman's Law also blocks rendaku, thereby avoiding creating an output

[11] Some Sino-Japanese nouns do undergo rendaku (Takayama 2005; see Chapter xx); those rendaku-undergoing items can be treated as nativized and hence subject to the general IDENT(VOI) constraint. Alternatively, it could be that these words form a new quasi-etymological category "Common Sino Japanese", and that they are subject to IDENT(VOI)$_{CSJ}$, which is ranked lower than REALIZE-M (Ito and Mester 2003a: 150-151).

[12] Ito and Mester (1995a) deploys reranking of constrains instead of indexation of constraints. For the general debate about the controversy between reranking and indexation of constraints to account for lexically-conditioned phonological patterns, see Antilla (2002), Inkelas and Zoll (2005, 2007), Inkelas (2011), Ito and Mester (1999, 2008), Pater (2010), Zamma (2012), among others.

that contains two voiced obstruents. Lyman's Law thus seems to apply both at the level of lexicon and at the output of phonological processes.

This dual nature of constraints was pointed out to be theoretically redundant (Ito and Mester 1986:67-68), a problem more generally known as "duplication problem", where linguistic generalizations need to be stated twice, both at the underlying level and at the surface level (Kenstowicz and Kisseberth 1977). Optimality Theory (Prince and Smolensky 1993/2004) overcomes this problem by eliminating conditions on underlying representations (the thesis known as "the Richness of the Base"; see McCarthy 2002:70-74, 178). In this sense, the duplication problem instantiated in Japanese—that Lyman's Law seems to hold both on underlying representations as well as the output of rendaku—may have had an influence on the birth of Optimality Theory.

5.1.3. Lyman's Law and dual nature of phonological constraints

Furthermore, in more recent years, it has been pointed out that Lyman's Law triggers devoicing of geminates in recent loanwords (Nishimura 2003, 2006; see section 3.5.5). Therefore, not only does Lyman's Law block a phonological process (rendaku), it also triggers a phonological process (devoicing) (Kawahara 2012). This observation is referred to as "conspiracy" in phonological theory (Kisseberth 1970a), and played an important role in promoting the role of phonological constraints, because rule-based theories cannot account for cases of conspiracy in a unified manner (McCarthy 2002: 62-63). See also Kawahara and Sano (2014) for another similar case of rendaku-related conspiracy, in which the Identity Avoidance constraint both triggers and blocks rendaku (see Chapter 8).

In short, Lyman's Law instantiates both a duplication problem and consipiracy, because it has three aspects: a restriction on the underlying forms, a blocker of rendaku, and a trigger of geminate devoicing in loanwords.

5.2. Remaining questions about theories of rendaku

There are some issues related to rendaku, which have not been fully discussed in the previous literature, which nevertheless merit some more discussion in future research.

One issue that we would like to raise is the question of whether rendaku is phonological or not. In the work reviewed above, rendaku is assumed to be phonological—hence assumed to bear on phonological theories in general—however, this point is rarely explicitly contended. See Kawahara (2014), Vance (2014) and Chapter 8 for a recent explicit discussion on this debate. See de Lacy (2009, 2014) and Kawahara (2011) for a recent summary of concerns about the quality of phonological data.

This issue is not a matter of all or nothing—it seems unpromising to us to say that rendaku is entirely phonological (with no lexical influences) or entirely lexical (without any phonological characteristics). A complete theory of rendaku, then, should delineate lexical and phonological aspects of rendaku, and offer proper accounts of both aspects.

Another remaining issue about rendaku is how to deal with the variation regarding rendaku. Rendaku involves lexical variation in three senses: (i) there is variation among items in such a way that some items undergo rendaku, and some others do not; (ii) there is sometimes an inter-speaker variation about whether some items undergo rendaku or not; (iii) even within a single speaker, there can be variation as to whether rendaku applies or not.[13] In recent years, theories of phonological variation have developed to account for these kinds of lexical variation (see Coetzee and Pater 2011; Coetzee and Kawahara 2013 for recent reviews), but they have not been applied to the study of rendaku. The previous theories reviewed in this chapter have dealt with regular exceptions, most notably Lyman's Law, but they have not dealt with item-specific behaviors. This is one aspect which we hope further theories of rendaku will tackle to model.

This issue is particularly important, because for those linguists who do not know Japanese, rendaku may be mistakenly taken as a regular, exception-less process. The textbook examples mentioned in section 1, for example, do not refer to lexical irregularity of rendaku (Gussenhoven and Jakob 2011: 58; Kenstowicz 1994: 493, 511-512; Roca 1994: 75-76; Spencer 1996: 60-61).[14] Anecdotally, the first author was told by a non-Japanese linguist that his student asked why /aka-gami/ 'red hair' undergoes rendaku, whereas /kuro-kami/ 'black hair' does not, that he had no answers to that question, and that he thought that rendaku was a regular, exception-less process. It is therefore important that the theoretical treatments of rendaku address both regular and irregular aspects of rendaku.

5.3. Final remarks

As discussed throughout this chapter, rendaku has been analyzed in various theoretical frameworks, and the analyses of rendaku have been developed in tandem with the development of phonological theories. We hope to have shown that the direction of the

[13] Theoretically speaking, the first issue is about lexical exceptionality (Kisseberth 1970b; Pater 2010), which has been treated with mechanisms like minor rules (Chomsky and Halle 1968) or constraint indexation (Pater 2000, 2010). The second issue is not often addressed in theoretical phonology, but is dealt with extensively in the sociolinguistic literature. The third issue is about optionality of phonological processes, and various models have been proposed to account for optional phonological processes in Optimality Theory (e.g. Antilla and Cho 1998; Antilla 2002; Boersma and Hayes 2001; Coetzee and Pater 2011; Zamma 2012; Zuraw 2000).

[14] This is not to say that Ito and Mester did not acknowledge such lexical irregularity. Ito and Mester (2003a: 149), for example, discuss a minimal pair like /kata-kana/ and /hira-gana/. However, they do note that "it is easy to overestimate the degree of irregularity and arbitrariness of the process…While the contrast is certainly noteworthy, it is at least equally significant that every other compounds with /kana/ in section position…show uniform voicing" (p.149). Ultimately, it is important to look at both regular and irregular aspects to achieve a full theoretical model of rendaku.

contribution was in no way one way: not only have contemporary theories been applied to analyses of rendaku, the analyses of rendaku themselves, most notably those by Ito and Mester, contributed to theoretical debates at that time, thereby leading to the development of phonological theory.

The recurrent theme in Ito and Mester's work, as we see it, is that they try to understand rendaku, especially its "bewildering", seemingly language-specific aspects, by deploying general phonological devices, which have been independently proposed elsewhere. This is why their work is so well-known and influential in the field of general phonology, even among those who are not interested in Japanese phonology *per se*.

Before closing this chapter, we would like to make one final remark. We have limited our discussion to those which had major impacts on phonological theory (in Japanese and beyond), but our overview is in no way comprehensive. Other generative treatments of various aspects of rendaku include, and is perhaps not limited to, Haraguchi (2001), Kurisu (2007), Nishimura (2007, 2013, 2014), Suzuki (1995, 1998), Rosen (2003), and Rice (2005).

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