The orthographic characterization of rendaku and Lyman's Law

Abstract

Rendaku is a process in Japanese by which the first consonant of a second member of a compound becomes voiced (e.g., /oo/ + /**t**ako/ → /oo+**d**ako/ 'big octopus'). Lyman's Law blocks rendaku when the second member already contains a voiced obstruent (/oo/ + /**t**oka**g**e/ → */oo+**d**oka**g**e/, /oo+**t**oka**g**e/ 'big lizard'). Lyman's Law, as a constraint which prohibits a morpheme with two voiced obstruents, is also known to trigger devoicing of geminates in loanwords (e.g. /**b**e**dd**o/ → /**b**e**tt**o/ 'bed'). Rendaku and Lyman's Law have been very well studied in the past phonological literature. Inspired by recent work that shows the interplay between orthographic factors and grammatical factors in shaping our phonological behaviors, this paper proposes a rather radical alternative interpretation of rendaku and Lyman's Law. Concretely, I argue that they operate over Japanese orthography. Rendaku is a process to assign *dakuten* diacritics, and Lyman's Law prohibits morphemes with two diacritics. The paper shows that various properties of rendaku and Lyman's Law follow from this proposal.

1 Introduction

Rendaku and Lyman's Law are probably some of the most well-studied phenomena in the phonological studies of Japanese (Irwin, 2016a; Vance & Irwin, 2016). A traditional description of rendaku is that "the first consonant of a second member of a compound becomes voiced"; e.g., /oo/ ' big' + /**t**ako/ 'octopus' → /oo+**d**ako/ 'big octopus'. Lyman's Law (Lyman, 1894; Vance, 2007) blocks rendaku when there is already another voiced obstruent in the second member of the compound; for example, /oo/ 'big' + /**t**oka**g**e/ 'lizard' → */oo+**d**oka**g**e/, /oo+**t**oka**g**e/ 'big lizard'. Rendaku and Lyman's Law were studied extensively

by the traditional grammarians (see Irwin 2016a), and were brought to the attention of theoretical linguists by Otsu (1980), who presented the first analysis of rendaku in the SPE-style (Chomsky & Halle, 1968).[1] Ito & Mester (1986) made rendaku and Lyman's Law famous in the field of theoretical phonology, as they analyzed rendaku and Lyman's Law using theoretical devices that were being developed at that time: autosegmental spreading, underspecification, and OCP (Obligatory Contour Principle). Later, Ito & Mester (2003a) developed a comprehensive reanalysis of rendaku and Lyman's Law within the framework of Optimality Theory (OT: Prince & Smolensky 2004). Reflecting the fact that they are now well-known in the field of theoretical phonology, rendaku and Lyman's Law appear in a number of introductory phonology textbooks (Gussenhoven & Jacobs 2011, p. 58; Kenstowicz 1994, p. 493, pp. 511-512; Roca 1994, pp. 75-76; Spencer 1996, pp. 60-61). Most generative studies on rendaku and Lyman's Law consider them to be phonological or morphophonological (see Kawahara 2015a and Vance 2014 for critical assessment of this view).

Building on some previous work (Kawahara, 2015a; Vance, 2015, 2016), this paper presents a radical alternative conception of rendaku and Lyman's Law, which explains their properties better than the purely phonological view. In essence, this paper proposes the following:

(1) Orthographic interpretations of rendaku and Lyman's Law.

a. Rendaku is an orthographic operation to add a *dakuten* mark, an orthographic diachritic to represent obstruent voicing.

b. Lyman's Law prohibits two occurrences of diacritics within a single morpheme.

Consider Table 1, which illustrates the basic Japanese *kana*-orthographic system, in which one letter generally corresponds to a (C)V mora. As shown in rows (a1-3), Japanese orthography marks voiced obstruents by putting two dots (called *dakuten*) on the upper right corner of the letter for the corresponding voiceless obstruents. As shown in (b), /b/ is written with *dakuten*

[1] The first comprehensive generative treatment of Japanese phonology appeared in McCawley (1968), but he gave up on the analysis of rendaku because he could not make sense of its irregularity.

on the letter for /h/. /p/ is represented by putting a little circle—known as *han-dakuten* 'half *dakuten*'—on the upper right corner of the letter for /h/, as in (c). Sonorant consonants and vowels, despite being phonetically voiced, are not written with *dakuten*, as in (d1-3).

Table 1: Basic Japanese *kana*-orthography systems.

	Sounds	Letters	Sounds	Letters
(a1)	ta	た	da	だ
(a2)	ka	か	ga	が
(a3)	sa	さ	za	ざ
(b)	ha	は	ba	ば
(c)	ha	は	pa	ぱ
(d1)	na	な	ma	ま
(d2)	ja	や	wa	ら
(d3)	na	わ	a	あ

This paper proposes that (i) rendaku is a process to assign *dakuten*, and that (ii) Lyman's Law prohibits two diacritics (*dakuten* or *han-dakuten*) within a morpheme. In this view, Lyman's Law is orthotactics (Bailey & Hahn, 2001) rather than phonotactics. Although this proposal may seem rather radical, it did not come out of the blue—Vance (2007, 2015, 2016) alerted the relevance of Japanese orthography in the patterning of rendaku, as we will see below. This proposal is also inspired by other work showing the interplay between orthographic and linguistic knowledge in shaping our phonological behaviors (Ito et al., 1996; Nagano & Shimada, 2014; Shaw et al., 2014).

2 Some properties of rendaku and Lyman's Law

Before developing the orthographic theory of rendaku and Lyman's Law, let us first review some crucial properties of rendaku (Kawahara & Zamma, 2016). As stated in the introduction, rendaku was first formalized in the SPE format by Otsu (1980), and later analyzed by a series of work by Ito and Mester (1986; 1996; 1997b; 2003a; 2003b). There are a number of theoretical contributions that they have made over the years, but this section focuses on those aspects that will become relevant later. First, rendaku has been treated as a manifestation of several grammatical operations, including a feature-changing SPE-style rule (Otsu, 1980), an

autosegmental spreading rule (Ito & Mester, 1986), morphophonologized intervocalic voicing (Ito & Mester, 1996), and morpheme realization (Ito & Mester, 2003a).

Second, rendaku has been discussed in the context of the internal organization of the Japanese lexicon (Ito & Mester, 1995, 1999, 2008) in that rendaku mainly occurs in native words, but very rarely occurs in loanwords. Third, Ito & Mester (1986) proposed that Lyman's Law is an instantiation of a universal constraint schema, the OCP on the [+voice] feature (Goldsmith, 1976; Leben, 1973; McCarthy, 1986). They further argued that OCP(+voice) acts as a morpheme structure condition on the Japanese lexicon as well, in that there are only a few native morphemes that contain two voiced obstruents.

Fourth, Lyman's Law is not triggered by [+voice] on sonorants, and hence Ito & Mester (1986) argued that the [+voice] feature is underspecified for sonorants. Mester & Ito (1989) argue instead that [voice] is a privative feature and sonorants do not bear that feature at all throughout the phonological derivation. Rice (1993) instead argues that sonorant voicing and obstruent voicing are represented by different features, and Lyman's Law targets only the latter. Alderete (1997) and Ito & Mester (2003b) formulated Lyman's Law as a result of self-conjunction of an OT constraint *VOICEOBS (=*D^2), which allows one not to commit themselves to a particular representation of [voice] for sonorants. This short review shows that rendaku and Lyman's Law have been extensively discussed in multiple theoretical frameworks (see Kawahara & Zamma 2016 for more details).

3 Arguments for orthographic explanations

3.1 Phonetic diversity, orthographic unity

Let us now turn to the orthographic theory of rendaku and Lyman's Law. The first argument to treat rendaku as a matter of orthography comes from the fact that when viewed from the phonetic point of view, rendaku is not simply a matter of "voicing of initial consonants", but instead involves more complicated parings of sounds (Vance, 2007, 2015, 2016). The surface phonetic pairs that are related by rendaku are shown in Table 2. In the left column, for each

pair, the original sound is shown on the left, and the one that appears after the application of rendaku is shown on the right. The middle column shows examples. The right column shows how these sounds are written before and after rendaku.

Table 2: Phonetic diversity, orthographic unity

	Phonetic pair	Example	Orthographic paring
(a)	[ɸ]–[b]	[ɸue]–[bue] ‘flute’	ふ vs. ぶ
(b)	[ç]–[b]	[çi]–[bi] ‘fire’	ひ vs. び
(c)	[h]–[b]	[ha]–[ba] ‘tooth’	は vs. ば
(d)	[t]–[d]	[ta]–[da] ‘field’	た vs. だ
(e)	[ts]–[z]	[tsuma]–[zuma] ‘wife’	つ vs. づ
(f)	[tɕ]-[ʑ]	[tɕikara]–[ʑikara] ‘power’	ち vs. ぢ
(g)	[k]–[g]	[ki]–[gi] ‘tree’	き vs. ぎ
(h)	[s]–[z]	[sora]–[zora] ‘sky’	そ vs. ぞ
(i)	[ɕ]–[ʑ]	[ɕima]–[ʑima] ‘island’	し vs. じ

Table 1 highlights the fact that rendaku is not simply a matter of “voicing the target consonant.” Among those in Table 1, (d, g, h, i) are straightforward minimal pairs that differ in voicing, but the others are not; for example, in (b), [ç] is a voiceless palatal fricative, but [b] is a voiced labial stop; in (c), [h] is a glottal fricative, but [b] is a labial stop; in (e) and (f), the original sounds are affricates, but the resulting sounds are fricatives. This complexity is not impossible to solve; for example, for (a-c), it is possible to posit an underlying labial stop /p/ (McCawley, 1968), which is realized as /h/ in non-voicing contexts and as /b/ in voicing contexts; /h/ further undergoes allophonic changes before /i/ and /u/, realizing as [çi] and [ɸu]. The deaffrication in (e, f) can be attributed to independently motivated intervocalic deaffrication (Maekawa, 2010), because rendaku usually occurs in intervocalic contexts.

It is not impossible to construct a phonological analysis of the complicated patterns in Table 2 in this way. However, it does face some problems. Most importantly, positing underlying /p/ for surface [h] can be problematic, because /p/ realizes faithfully in native words as well, as in *tampopo* ‘dandelion’ and *paipan* ‘shaved genitalia’ (Fukazawa & Kitahara, 2002). Moreover, a reversing argot pattern in Japanese (Ito et al., 1996) shows that the process that turns underlying /p/ to [h] is not active even for native items; e.g. /kappa/ → /**p**akka/, */**h**akka/

'river imp' and /oppai/ → /**p**aiotsu/, */**h**aiotsu/ 'breast'.[2]

More crucially, it is important to note that from the view point of orthography, all the pairings in Table 2 can be treated as an addition of the same diacritic mark (*dakuten*) (Vance, 2015, 2016). All the letters for the sounds that appear on the right are identical to those letters that represent the sounds on the left, with addition of the *dakuten* diacritic mark. Rendaku therefore can simply be understood as "the addition of a *dakuten* mark". As Vance (2016) says, "the Japanese writing system represents all the [rendaku] alternations in a uniform way" (p.3 of the manuscript version).

3.2 /p/-driven geminate devoicing

The second argument comes from the patterns of geminate devoicing found in loanwords, which is demonstrably caused by Lyman's Law. In Japanese loanwords, geminates can devoice when they co-occur with another voiced obstruent (e.g. /**b**e**dd**o/ → /**b**e**tt**o/ 'bed'), but not when voiced geminates do not appear with an additional voiced obstruent (/**h**e**dd**o/ → /**h**e**dd**o/, */**h**e**tt**o/ 'head') (Kawahara, 2006, 2011a, 2015b; Nishimura, 2006). As Nishimura (2006) and Kawahara (2006) argue, this devoicing can be understood as an effect of Lyman's Law, because devoicing avoids morphemes with two voiced obstruents. Interestingly, /p/ seems to cause devoicing of geminates as well (e.g. /**p**irami**dd**o/ → /**p**irami**tt**o/ 'pyramid'; /kjuu**p**i**dd**o/ → /kjuu**p**i**tt**o/ 'cupid').

Since this /p/-driven devoicing of geminates seems counterintuitive, Kawahara & Sano (2016) ran a judgment experiment to investigate whether this devoicing is real. In this experiment, they presented native speakers of Japanese with a list of words that contain particular sorts of structures: (i) geminates that appear with /p/ (e.g. /**p**a**dd**o/ 'pad'), (ii) Lyman's Law-violating geminates (e.g. /**b**a**dd**o/ 'bad'), (iii) non-Lyman's-Law-violating geminates (e.g.

[2]Why does /tsu/ emerge in the last syllable? This is because the gemination is marked with a smaller version of the letter for /tsu/ (っ) in the Japanese orthography. Thus, in terms of orthography, this argot can be expressed as おっぱい → ぱいおつ. This is another example in which orthography offers a straightforward explanation for the sound pattern under question (Ito et al., 1996).

/he**dd**o/ ‘head’), (iv) Lyman’s Law-violating singletons (e.g. /**b**aa**d**o/ ‘bird’), and (v) non-Lyman’s Law-violating singletons (e.g. /haa**d**o/ ‘hard’). In that experiment, for each word, they presented to the participants two forms, one “faithful form” (e.g. /be**dd**o/) and one “de-voiced form” (e.g. /be**tt**o/), and asked them which pronunciation they would use. The results, reproduced in Figure 1, show that geminates are indeed pronounced as devoiced 40% or 30% of the time when they co-occur with /p/ or another voiced obstruent; the results also show, on the other hand, that other conditions show very few devoiced responses—most importantly, context-free devoicing of geminates rarely occurs. See Kawahara & Sano (2016) for the corpus data, generally suggesting the same pattern.

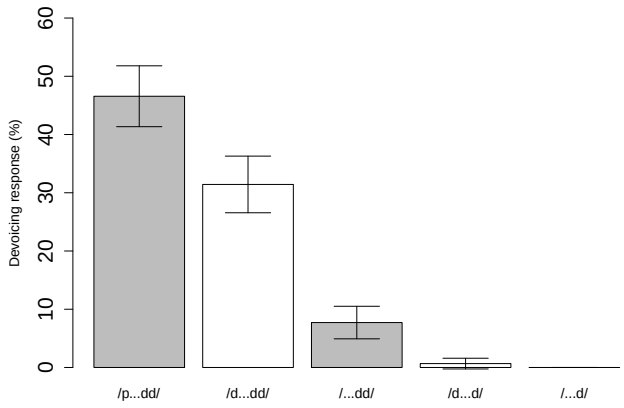

Figure 1: Devoicability of each type of consonant. Based on Kawahara & Sano (2016).

Why would /p/ cause devoicing of geminates, or in other words, why does /p/ trigger Lyman’s Law? OCP(+voice) (Ito & Mester, 1986) or *D^2 (Ito & Mester, 2003a) cannot be the explanation, because /p/ is not a voiced obstruent—it would turn into /b/ if it were [+voice]. If Lyman’s Law prohibits two diacritics within a morpheme, this /p/-driven devoicing makes sense, because /p/ also has a diacritic mark (*han-dakuten*: see Table 1). In summary, the trigger of geminate devoicing in Japanese loanwords includes /p, b, d, g/. There does not seem to be a phonological natural class to characterize this group of sounds. However, all of these sounds have an orthographic diacritic in Japanese: ぱ, ば, だ, が.

Mark Irwin (p.c.) pointed out that this theory makes a certain prediction about geminate

devoicing. Since devoicing /bb/ would result in /pp/, which would still have a diacritic mark, /bb/ should not devoice. Loanwords containing /bb/ are rare in the first place (Katayama, 1998; Shirai, 2002), but there is one word that contains both /bb/ and a voiced stop, /**g**e**bb**erusu/ 'Göbbels," and the prediction seems to be borne out. In the naturalness judgment using a 5-point scale reported by Kawahara (2011a), the devoicing of this word was rated much less natural than the devoicing of geminates in other Lyman's-Law-violating words: 3.16 vs. 3.86. This score (3.16) is in fact *lower* than the average naturalness of devoicing of non-Lyman's-Law-violating words (3.26), whose devoicing was deemed almost impossible in Kawahara & Sano (2016) (see Figure 1). This result further supports the formulation of Lyman's Law as the orthotactic which prohibits two diacritics.[3]

3.3 Explaining why sonorants do not cause Lyman's Law

Treating rendaku and Lyman's Law as a matter of orthography comes with additional virtues. Recall that Lyman's Law ignores voicing in sonorants and vowels, and that several theoretical apparatuses were proposed to account for that observation: underspecification (Ito & Mester, 1986), privative feature (Mester & Ito, 1989), or obstruent-specific voicing feature (Rice, 1993). However, there is a simple explanation in terms of orthography: as shown in Table 1, Japanese orthography marks voicing on obstruents with a diacritic mark, but not on sonorants. Therefore, if Lyman's Law were to be understood as a prohibition against two diacritics, then the inactivity of sonorant voicing directly follows. No additional machinery is necessary.

3.4 Explaining the opacity

Another piece of evidence comes from the interaction of rendaku, Lyman's Law, and yet another phonological process. In some dialects of Japanese, intervocalic [ɡ] becomes [ŋ]

[3] Another possible candidate is /**g**u**bb**ai/ 'Good bye', which is arguably heteromorphemic, and thus has not been tested in the previous judgment experiments. I have consulted a few native speakers about the possibility of devoicing this /bb/ in /**g**u**bb**ai/—many feel that it is impossible to devoice /bb/ for this word too, to the degree that they laugh at the devoiced form of this word.

(Ito & Mester, 1997a, 2003b; Vance, 1987). This segment [ŋ] is not a voiced obstruent, but it still blocks rendaku, as in [saka-toŋe] 'reverse thorn' and [oo-tokaŋe] 'big lizard'.

This interaction is opaque because the surface [ŋ] acts as if it is a voiced obstruent: 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, despite the application of velar nasalization. In a derivational sense, velar nasalization needs to occur after rendaku applies; when rendaku occurs, /g/ is still /g/ (Table 3). Ito & Mester (2003b) developed this derivational ordering analysis in OT (Prince & Smolensky, 2004). Ito & Mester (1997b) and Honma (2001) instead proposed analyses based on Sympathy Theory (McCarthy, 1999).

Table 3: Derivational analysis of the opacity.

	The right order		The wrong order	
UR	/saka+toge/		UR	/saka+toge/
rendaku velar nasalization	—blocked by Lyman's Law— /saka+toŋe/		velar nasalization rendaku	/saka+toŋe/ /saka+doŋe/
SR	[saka+toŋe]		SR	*[saka+doŋe]

One particular challenge that this opaque pattern presents is as follows. Since [g] and [ŋ] are in an allophonic relationship, the Richness of the Base hypothesis makes us consider a case in which [ŋ] appears in the input; e.g. /toŋe/. In order for this form to block rendaku, the underlying /ŋ/ has to be changed to /g/, and then has to turn back to /ŋ/. This pattern would thus instantiate a "Duke-of-York" derivation (Pullum, 1976) (schematically, /A/ → /B/ → [A]), whose existence is debatable (McCarthy, 2003; Rubach, 2003; Wilson, 2000).

The orthographic formulation of Lyman's Law explains explain why /g/, after becoming [ŋ], would still block rendaku, because [ŋ] is still written with a *dakuten* mark (velar nasalization is not reflected in the Japanese orthography). No theoretical machinery is necessary, and in particular, this view does away with the derivational ordering analysis. See arguments by Hooper (1976), Sanders (2003), Green (2004) and Padgett (2010) that there are perhaps no productive synchronic cases of opacity.[4]

[4]Bruce Hayes also mentions some statement to this effect in his lecture at "50 Years of Linguistics at MIT",

One may argue that devices such as underspeficication, privative features, derivational opacity, or a Duke-of-York derivation are independently necessary, so the last two arguments developed in this section are not as strong. It may actually turn out that these notions are indeed necessary in phonological theory. However, it is important to emphasize here that the orthographic theory of rendaku and Lyman's Law explains the clustering of their properties without further additional machineries.

4 Conclusion

In summary, many properties of rendaku and Lyman's Law make sense, once we consider them from the viewpoint of Japanese orthography. When viewed at the surface phonetic level, rendaku is not a simple matter of "voicing the target consonant", but involves different sets of more complicated pairings. However, in terms of orthography, rendaku is simply an addition of *dakuten*. Treating Lyman's Law as orthotactics comes with three additional virtues: (i) it explains why /p/ can cause devoicing of geminates; (ii) it explains why Lyman's Law ignores [+voice] of sonorants; and (iii) it explains why /g/ blocks rendaku, after it turns into /ŋ/.

The orthographic theory of rendaku and Lyman's Law makes one more prediction, which is unfortunately not easy to test—/p/ should block rendaku, because it should trigger Lyman's Law. Unfortunately, rendaku applies mainly to native items, and native items rarely contain /p/, because Japanese lost this phoneme at some point in its history (Ito & Mester, 1995, 1999, 2008).[5] In the rendaku database (Irwin, 2016b; Irwin & Miyashita, 2016), there is one monomorphemic native word that contains /p/ or /pp/, *suppai* 'sour', which undergoes rendaku. This word would have to be treated as an exception. There are two more relevant native words *happa* 'leaves' and *sippo* 'tail', neither of which undergoes rendaku (Vance, 2007) . An-

which succinctly summarizes the problem: "We don't understand the opaque languages well enough. In particular, I don't think we fully understand the degree to which the opaque pattern is internalized by language learners, and it is time to do more checking" (viewable on Youtube).

[5]Interestingly, though, Lyman (1894) himself argues that /p/ blocks rendaku: "the second part of a compound word takes the nigori [=rendaku]; that is if beginning with ch, f, h, k, s, sh, or t, those consonants are changed into the corresponding sonant [=voiced] ones ... the general rule does not apply ... when b, d, g, j, p, or z already occurs anywhere in the second part of the compound" (p.2). See also Vance (2007).

other relevant word *kappa* 'coat' undergoes rendaku, contra the prediction of the orthographic theory of Lyman's Law. This word, however, is doubly exceptional, because this word is a loanword (recall that rendaku is usually limited to native words). Overall, there are exceptions for the original formulation of Lyman's Law based on [+voice] as well (e.g. *hasigo* and *saburoo*, which undergo rendaku)—I thus contend that these exceptions are not detrimental to the orthographic theory of Lyman's Law.

Table 4: Summary.

	Triggering devoicing	Blocking rendaku	[+voice]	[+voice, -son]	diacritic
/b/	yes	yes	+	+	+
/d/	yes	yes	+	+	+
/g/	yes	yes	+	+	+
/p/	yes	?	-	-	+
/t/	no	no	-	-	-
/k/	no	no	-	-	-
/m/	no	no	+	-	-
/n/	no	no	+	-	-
/ŋ/	?	yes	+	-	+

Table 4 provides a summary of what has been discussed in the paper. The leftmost column shows whether each segment triggers devoicing of geminates or not. Whether /ŋ/ triggers devoicing of geminates is unclear, because there are no words with a voiced geminate and an intervocalic /g/ (and no other potential trigger).[6] The second column shows whether each segment blocks rendaku or not. The third column shows whether they are phonetically voiced or not. The fourth column shows voicing in obstruents (which would be "plus" under the underspecification theory, for example). The last column shows whether each sound is written with a diacritic mark or not. It seems that the last column matches the first two columns best.

One interesting line of research that should come out of this proposal is to address what preliterate children do. There has not been much longitudinal work on the acquisition of rendaku; Sugimoto (2013) is one exception, who shows that Japanese children acquire rendaku

[6]The word /bagudaddo/ 'Bagdad' contains an intervocalic /g/ and a voiced geminate, but it also contains other voiced obstruents.

gradually. It would be interesting to test whether this gradual acquisition of rendaku correlates with the acquisition of literacy, which is also expected to be gradual.

To close this paper, I want to raise one cautionary remark. Even if the current proposal is on the right track, we need to make sure not to throw the baby out with the bathwater; i.e. banishing rendaku and Lyman's Law from the field of phonology entirely. Recent work shows that orthographic knowledge may have a deep connection with our linguistic knowledge (Ito et al., 1996; Nagano & Shimada, 2014; Shaw et al., 2014). I do not mean to argue that every aspect of rendaku can be reduced to orthography. Rendaku for instance interacts with several kinds of linguistic information, such as branching structures and morphosyntactic categories (Vance & Irwin, 2016), which cannot be reduced to orthography. It is also important to note that in the loanword devoicing pattern, only voiced geminates, not singletons, can get devoiced in response to Lyman's Law, as shown in Figure 1—i.e. devoicing due to Lyman's Law is delineated by a grammatical distinction like singletons vs. geminates (Kawahara, 2006, to appear). It thus seems most productive to consider the interplay of orthography and other grammatical principles to explain our linguistic behavior. Japanese speakers should have an orthographic representation as a part of their linguistic knowledge (cf. Nagano & Shimada 2014), and that representation can affect their speech behavior, in tandem with phonological and other linguistic representations.

References

Alderete, John (1997) Dissimilation as local conjunction. In *Proceedings of the North East Linguistics Society 27*, Kiyomi Kusumoto, ed., Amherst: GLSA, 17–31.

Bailey, Todd & Ulrike Hahn (2001) Determinants of wordlikeliness: Phonotactics or lexical neighborhoods? *Journal of Memory and Language* **44**: 568–591.

Chomsky, Noam & Moris Halle (1968) *The Sound Pattern of English*. New York: Harper and Row.

Fukazawa, Haruka & Mafuyu Kitahara (2002) Degree of specification in markedness constraints. *On-in Kenkyu [Phonological Studies]* **5**: 13–20.

Fukazawa, Haruka, Mafuyu Kitahara, & Mitsuhiko Ota (2002) Acquisition of phonological sub-lexica in Japanese: An OT account. In *Proceedings of the Third Tokyo Conference on Psycholinguistics*, Yukio Otsu, ed., Tokyo: Hitsuji Shobo, 97–114.

Goldsmith, John (1976) *Autosegmental Phonology*. Doctoral dissertation, MIT.

Green, Antony (2004) Opacity in Tiberian Hebrew: Morphology, not phonology. *ZAS Papers in Linguistics* **37**: 37–70.

Gussenhoven, Carlos & Haike Jacobs (2011) *Understanding Phonology, 3rd Edition*. Oxford: Oxford University Press.

Honma, Takeru (2001) How should we represent 'g' in *toge* in Japanese underlyingly? In *Issues in Japanese Phonology and Morphology*, Jeroen Van de Weijer & Tetsuo Nishihara, eds., Berlin & New York: Mouton de Gruyter, 67–84.

Hooper, Joan (1976) *An Introduction to Natural Generative Phonology*. New York: Academic Press.

Irwin, Mark (2016a) A rendaku bibliography. In *Sequential voicing in Japanese compounds: Papers from the NINJAL Rendaku Project*, Timothy Vance & Mark Irwin, eds., 235-250, Berlin: John Benjamins.

Irwin, Mark (2016b) The rendaku database. In *Sequential voicing in Japanese compounds: Papers from the NINJAL Rendaku Project*, Timothy Vance & Mark Irwin, eds., John Benjamins, 79–106.

Irwin, Mark & Mizuki Miyashita (2016) The Rendaku Database v.2.7.

Ito, Junko, Yoshihisa Kitagawa, & Armin Mester (1996) Prosodic faithfulness and correspondence: Evidence from a Japanese argot. *Journal of East Asian Linguistics* **5**: 217–294.

Ito, Junko & Armin Mester (1986) The phonology of voicing in Japanese: Theoretical consequences for morphological accessibility. *Linguistic Inquiry* **17**: 49–73.

Ito, Junko & Armin Mester (1995) Japanese phonology. In *The Handbook of Phonological Theory*, John Goldsmith, ed., Oxford: Blackwell, 817–838.

Ito, Junko & Armin Mester (1996) Rendaku I: Constraint conjunction and the OCP. Ms. University of California, Santa Cruz.

Ito, Junko & Armin Mester (1997a) Correspondence and compositionality: The ga-gyo variation in Japanese phonology. In *Derivations and Constraints in Phonology*, Iggy Roca, ed., Oxford: Oxford University Press, 419–462.

Ito, Junko & Armin Mester (1997b) Featural sympathy: Feeding and counterfeeding interactions in Japanese. *Phonology at Santa Cruz* **5**: 29–36.

Ito, Junko & Armin Mester (1999) The phonological lexicon. In *The Handbook of Japanese*

Linguistics, Natsuko Tsujimura, ed., Oxford: Blackwell, 62–100.
Ito, Junko & Armin Mester (2003a) *Japanese Morphophonemics*. Cambridge: MIT Press.
Ito, Junko & Armin Mester (2003b) Lexical and postlexical phonology in Optimality Theory: Evidence from Japanese. *Linguistische Berichte* **11**: 183–207.
Ito, Junko & Armin Mester (2008) Lexical classes in phonology. In *The Oxford Handbook of Japanese Linguistics*, Shigeru Miyagawa & Mamoru Saito, eds., Oxford: Oxford University Press, 84–106.
Katayama, Motoko (1998) *Optimality Theory and Japanese loanword phonology*. Doctoral dissertation, University of California, Santa Cruz.
Kawahara, Shigeto (2006) A faithfulness ranking projected from a perceptibility scale: The case of [+voice] in Japanese. *Language* **82**(3): 536–574.
Kawahara, Shigeto (2011a) Aspects of Japanese loanword devoicing. *Journal of East Asian Linguistics* **20**(2): 169–194.
Kawahara, Shigeto (2011b) Japanese loanword devoicing revisited: A rating study. *Natural Language and Linguistic Theory* **29**(3): 705–723.
Kawahara, Shigeto (2015a) Can we use rendaku for phonological argumentation? *Linguistic Vanguard* **1**: 3–14.
Kawahara, Shigeto (2015b) Geminate devoicing in Japanese loanwords: Theoretical and experimental investigations. *Language and Linguistic Compass* **9**(4): 168–182.
Kawahara, Shigeto (to appear) Japanese geminate devoicing once again: Insights from information theoryvoicing once again: Insights from information theory. *Proceedings of Formal Approaches to Japanese Linguistics 8* .
Kawahara, Shigeto & Shin-ichiro Sano (2016) /p/-driven geminate devoicing in Japanese: Corpus and experimental evidence. *Journal of Japanese Linguistics* **32**.
Kawahara, Shigeto & Hideki Zamma (2016) Generative treatments of rendaku. In *Sequential voicing in Japanese compounds: Papers from the NINJAL Rendaku Project*, Timothy Vance & Mark Irwin, eds., Amsterdam: John Benjamins, 13–34.
Kenstowicz, Michael (1994) *Phonology in Generative Grammar*. Oxford: Blackwell.
Leben, Will (1973) *Suprasegmental Phonology*. Doctoral dissertation, MIT.
Lyman, Benjamin S. (1894) Change from surd to sonant in Japanese compounds. *Oriental Studies of the Oriental Club of Philadelphia* : 1–17.
Maekawa, Kikuo (2010) Coarticulatory reintrepretation of allophonic variation: Corpus-based analysis of /z/ in spontaneous Japanese. *Journal of Phonetics* **38**(3): 360–374.
McCarthy, John J. (1986) OCP Effects: Gemination and antigemination. *Linguistic Inquiry* **17**: 207–263.
McCarthy, John J. (1999) Sympathy and phonological opacity. *Phonology* **16**: 331–399.
McCarthy, John J. (2003) Sympathy, cumulativity, and the Duke-of-York gambit. In *The Syllable in Optimality Theory*, Caroline Féry & Ruben van de Vijver, eds., 23-76, Cambridge: Cambridge University Press.
McCawley, James D. (1968) *The Phonological Component of a Grammar of Japanese*. The Hague: Mouton.
Mester, Armin & Junko Ito (1989) Feature predictability and underspecification: Palatal prosody in Japanese mimetics. *Language* **65**: 258–293.
Nagano, Akiko & Masaharu Shimada (2014) Morphological theory and orthography: Kanji

as a representation of lexemes. *Journal of Linguistics* **50**(2): 323–364.
Nishimura, Kohei (2006) Lyman's Law in loanwords. *On'in Kenkyu [Phonological Studies]* **9**: 83–90.
Otsu, Yukio (1980) Some aspects of rendaku in Japanese and related problems. In *MIT Working Papers in Linguistics*, vol. 2, Ann Farmer & Yukio Otsu, eds., Cambridge, Mass.: Department of Linguistics and Philosophy, MIT, 207–228.
Padgett, Jaye (2010) Russian consonant-vowel interactions and derivational opacity. In *Proceedings of 18th Formal Approaches to Slavis Linguistics*, W. Brown, A Cooper, A Fosher, E. Kesici, Predolac N., & D. Zec, eds., Ann Arbor: Michigan Slavic Publications, 353–382.
Prince, Alan & Paul Smolensky (2004) *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden and Oxford: Blackwell.
Pullum, Geoffrey (1976) The Duke of York gambit. *Journal of Linguistics* **12**: 83–102.
Rice, Keren (1993) A reexamination of the feature [sonorant]: The status of sonorant obstruents. *Language* **69**: 308–344.
Roca, Iggy (1994) *Generative phonology*. Taylor & Francis Ltd.
Rubach, Jerzy (2003) Duke-of-York derivations in Polish. *Linquistic Inquiry* **34**(4): 601–629.
Sanders, Nathan (2003) *Opacity and Sound Change in the Polish Lexicon*. Doctoral dissertation, University of California, Santa Cruz.
Shaw, Jason, Chong Han, & Yuan Ma (2014) Surviving truncation: Informativity at the interface of morphology and phonology. *Morphology* **24**: 407–432.
Shirai, Setsuko (2002) *Gemination in Loans from English to Japanese*. MA thesis, University of Washington.
Spencer, Andrew (1996) *Phonology: Theory and description*. Oxford: Blackwell.
Sugimoto, Takayo (2013) Yooji-no rendaku-no kakutoku-ni kansuru oudanteki kenkyuu–goshu-to raiman-no hoosoku-wo chuushin-ni. Talk delivered at Nihon Gengogakkai, 2013.
Vance, Timothy (1987) *An Introduction to Japanese Phonology*. New York: SUNY Press.
Vance, Timothy (2007) Have we learned anything about *rendaku* that Lyman didn't already know? In *Current issues in the history and structure of Japanese*, Bjarke Frellesvig, Masayoshi Shibatani, & John Carles Smith, eds., Tokyo: Kurosio, 153–170.
Vance, Timothy (2014) If rendaku isn't a rule, what in the world is it? In *Usage-Based Approaches to Japanese Grammar: Towards the Understanding of Human Language,*, Kaori Kabata & Tsuyoshi Ono, eds., Amsterdam: John Benjamins, 137–152.
Vance, Timothy (2015) Rendaku. In *The Handbook of Japanese Language and Linguistics: Phonetics and Phonology*, Haruo Kubozono, ed., Berlin: Mouton de Gruyter, 397–441.
Vance, Timothy (2016) Introduction. In *Sequential voicing in Japanese compounds: Papers from the NINJAL Rendaku Project*, Timothy Vance & Mark Irwin, eds., Berlin: John Benjamins, 1–12.
Vance, Timothy & Mark Irwin, eds. (2016) *Sequential voicing in Japanese compounds: Papers from the NINJAL Rendaku Project*. John Benjamins.
Wilson, Colin (2000) *Targeted Constraints: An Approach to Contextual Neutralization in Optimality Theory*. Doctoral dissertation, Johns Hopkins University.