Can we use rendaku for phonological argumentation?

Abstract

This paper addresses the general issue of the quality of phonological data, using rendaku as a case study. Rendaku is a well-known voicing process that accompanies compound formation in Japanese. The issue of the quality of phonological data has been discussed from time to time from various perspectives throughout the history of phonological research, with recent renewed interests. This paper takes up rendaku as a case study to discuss this issue, because, rendaku has been used to argue for many theoretical apparatuses, and has appeared in many textbooks, but it is rarely acknowledged in the theoretical literature that rendaku involves extensive lexical irregularity. The specific question addressed in this study is whether it is appropriate to use rendaku for phonological argumentation. Ultimately, the answer that this paper will propose is yes, but the more crucial lesson is that the theoretical phonology should examine the quality of phonological data more explicitly.

1 Introduction

1.1 Synopsis

This paper addresses the general issue of the quality of phonological data using rendaku as a case study. Rendaku is a well-known voicing process that accompanies compound formation in Japanese. The issue of the quality of phonological data has been discussed from time to time from various perspectives throughout the history of phonological research, with recent renewed interests. This paper takes up rendaku as a case study to discuss this issue, because, rendaku has been used to argue for many theoretical apparatuses, and has appeared in many introductory textbooks, but it is rarely acknowledged in the theoretical literature that rendaku involves extensive lexical irregularity. The specific question addressed in this study is whether it is appropriate to use rendaku for phonological argumentation. Ultimately, the answer that this paper will propose is yes, but the more crucial lesson is that the theoretical phonology should examine the quality of phonological data more carefully and explicitly.

The rest of this paper proceeds as follows. Section 1 summarizes recent arguments that phonological data should be examined more carefully than the normal standard practiced in the current

field of phonology. Section 2 provides a brief overview of rendaku, and explains why we should examine the question of whether we can use rendaku for phonological argumentation carefully. Section 3 and section 4 provide positive evidence that rendaku does at least have phonological aspects, if not it is entirely phonological, which justifies the use of rendaku in phonological argumentation. Section 5 discusses one remaining thorny issue—the effects of orthography. The final section concludes.

1.2 Theoretical background

Phonologists analyze phonological processes where some sounds change with other sounds, and construct phonological theory based on these analyses.[1] However, several researchers have pointed out that it is dangerous to use any kind of such "apparent" sound change patterns. There are several types of this sort of argument, which are briefly reviewed here (see de Lacy 2009, Kawahara 2011a and Kawahara 2011b for recent reviews; see also Schütze 1996 and subsequent work for the related discussion in syntax).

One type of warning comes from the observation that some sound changes involve gradient changes rather than categorical changes. For example, in some dialects of English, coda [l] is velarized, and it is tempting to use this process for phonological argumentation. Sproat & Fujimura (1993) show however that the degree of velarization is gradient (i.e. it is not a matter of yes-velarized or not-velarized), and the degree of velarization in coda correlates with the strength of phrase boundaries at which the [l] is located (see also Lee-Kim et al. 2013). Similarly, Nolan (1992) found that in English phrasal assimilation patterns, where word-final coronal consonants appear to assimilate to the following dorsal consonants (as in "late call"), the assimilation is not complete: [t] in "late" does not fully become [k] even when "assimilation" seems to have taken place. Although a later study by Ellis & Hardcastle (2002) found that at least some speakers show categorical changes, this general finding offers us a good lesson—some apparent "phonological patterns" should be better treated as a matter of phonetic implementations, and should probably not used for phonological argumentation. Other phenomena of this kind include, but are not limited to, Arabic tongue back spreading (Keating, 1990), English intrusive stop insertion (Fourakis & Port, 1986), English vowel nasaliaztion (Cohn, 1993), English glide insertion (Davidson & Erker, 2014), French schwa deletion (Fougeron & Steriade, 1997), and Japanese tonal spreading (Pierrehumbert & Beckman, 1988).

Another type of argument comes from the observation that some sound change patterns are not replicable with nonce words, and therefore its productivity is in doubt. This concern was raised

[1] This paper sets aside the issue of phonotactics. Whether phonotactic knowledge is grammar-governed or statistically learned is an also important issue (see e.g. Berent et al. 2007; Clements 1990; Daland et al. 2011; Frisch et al. 2004a; Greenberg & Jenkins 1964; Kager & Pater 2012; Ohala 1986), but this paper remains neutral about this debate.

against the generative phonological research enterprise as early as Ohala (1974), who addresses the productivity of velar softening in English (see also Pierrehumbert 2006). To take an example from Japanese, the past tense formation involves various sound change proceses (e.g. post-nasal voicing, velar deletion, epenthesis, etc). Vance (1987), in Chapter 12 of his book, however, shows that these sound changes are not replicated in experimental settings. Later studies consistently fail to systematically replicate the alleged "phonological" patterns that appear in the Japanese past tense formation (Batchelder, 1999; Griner, 2001; Vance, 1991). The fact that the sound change patterns in the past tense formation are not productive unfortunately went unacknowledged in theoretical linguistics and have been used for some theoretical analyses (Davis & Tsujimura, 1991; Ito & Mester, 1995; Ito et al., 1995, 1999; Lombardi, 2002; Rice, 1993, 2005). This is particularly unfortunate because the failure to replicate the existing patterns in nonce words is explicitly reported in a well-known introductory book on Japanese phonology (Vance, 1987). As Vance (1991, p. 156) states, "[the experimental result] is consistent with the claim that even morphologically regular Japanese verb forms are stored in the lexicon." To the extent that phonological theory is about a *generative* component of a grammar, phonological theory should be based on processes that are productive, not forms that are stored in the lexicon. See Sanders (2003) for a similar case from Polish; see also Zimmer (1969) for tests of morpheme structure conditions in Turkish, which show that only a subset of the conditions is replicated with nonce words.

The third type of concern comes from the lack of sufficient number of examples. This concern can again be illustrated using a pattern in Japanese phonology. The palatalization patterns found in mimetic forms have been argued to instantiate a case of conflicting directionality (Zoll, 1997), in which coronal and non-coronal consonants show different directionality effects when they attract the palatalization morpheme (Hamano, 1986; Kurisu, 2009; Mester & Ito, 1989; Zoll, 1997). Alderete & Kochetov (2009) show however that there are not many examples supporting this claim, and there are also a number of counterexamples (see also Schourup & Tamori 1992); their informants did not replicate the expected patterns either. Therefore, all in all it seems important to make generalizations based on a sufficient number of examples (de Lacy, 2007, 2014).

To summarize then, not every sound change patterns should be taken to be phonological. Some patterns may be implemented in the phonetic component of grammar, while others are not productive. These concerns did not entirely go unacknowledged among theoretical and experimental phonologists throughout the history of phonological theory (de Lacy, 2007, 2009, 2014; Hayes, 1995; Kawahara, 2011a,b; Ohala, 1974, 1986; McCawley, 1986; Nolan, 1992). For example, Hayes states "I occasionally wondered, Where is the normal phonology that I was trained to study?" (Hayes, 1995, 68)—processes that seem to apply more or less automatically without exceptions now appear to be "phonetic-y" and those morphophological patterns that do not seem irrelevant to phonetics appear to be non-productive and come with many exceptions. Needless to say, it is not

the case that phonology is entirely "gone" (we would hope), unlike this statement implies, but it is clear that given the concerns reviewed in this section, the quality of phonological data should be examined more carefully before used for phonological argumentation (for recent restatements of this thesis, see de Lacy 2007, 2009, 2014; Kawahara 2011a,b; see also Schütze 1996).

2 A case study: rendaku

2.1 What rendaku is

With these concerns in mind, this paper examines rendaku focusing on the question of whether we can use rendaku for phonological argumentation. Rendaku is a well-known juncture phenomenon in Japanese that accompanies compound formation (e.g. /oo+**t**anuki/ → /oo-**d**anuki/ 'big raccoon').[2] The way phonologists often put it is: "the initial consonant of a second member of compounds become voiced"—for example, a classic theoretical work by Ito & Mester (1986) introduces rendaku as follows (p.50): "a rule of sequential voicing—Rendaku—voices initial obstruents in second elements of compounds".

A more lexically-oriented characterization is found for example by authors such as Vance (2014a). To quote:

> Many Japanese morphemes exhibit a well-known voicing phenomenon called rendaku...Such a morpheme has one allomorph beginning with a voiceless obstruent and another allomorph beginning with a voiced obstruent. An example is a morpheme meaning 'bird': it appears with voiceless initial /t/ in /tori/...'bird'...and it appears with voiced initial /d/ in /hati+dori/...'hummingbird'. When a morpheme shows this kind of alternation, the allomorph that begins with a voiced obstruent can appear only non-word-initially, and it is customary to say that rendaku occurs in a word that contains this allomorph (p.137 with slight medications on transcription).

This characterization of rendaku treats rendaku as a matter of the distribution of two allomorphs, and does not posit or imply the existence of "a phonological voicing rule".

The reason behind this careful wording is perhaps because rendaku involves much lexical irregularity. Vance (2014b) provides a recent overview on various factors that affect the applicability of rendaku; Vance & Irwin (to appear) offer a comprehensive collection of overviews of various aspects of rendaku, including its lexical irregularity. Most importantly, it is often not predictable whether rendaku applies to a particular lexical item or not. Some examples are shown in (1):

[2]For the sake of simplicity, this paper uses standard phonemic transcription system rather than the IPA transcription (Vance, 2008), except where the phonetic details are relevant.

(1) Lexical irregularity of rendaku

a. /kuro-**k**ami/ ‘black hair’ vs. /aka-**g**ami/ ‘red hair’

b. /kata-**k**ana/ ‘katakana spelling’ vs. /hira-**g**ana/ ‘hiragana spelling’

c. /niwa-**t**ori/ ‘chicken’ vs. /yama-**d**ori/ ‘mountain bird’

d. /ero-**h**on/ ‘porn magazines’ vs. /bini-**b**on/ ‘porn magazines’

e. /asi-**k**use/ ‘leg habit’ vs. /kuti-**g**use/ ‘mouth habit’

In addition, there are some items that never undergo rendaku, even when these items violate no constraints that systematically inhibit rendaku application (e.g. /kemuri/ ‘smoke’ and /tuyu/ ‘dew’: Vance 2014a, p.140). For these items, there are no phonological or morphological reasons for rendaku not to occur, but rendaku does not apply.

There is nothing new about these observations—the first comprehensive generative treatment of the Japanese phonology by McCawley (1968) states that he is “unable to state the environment in which the “voicing rul” applies...[t]he relevant data are completely bewildering” (footnote 18—see pp.86-87). Emphasizing on its lexical irregularity, Ohno (2000) goes so far as to propose that rendaku should entirely be treated as a matter of lexical analogy, not a phonological rule: “rendaku is not a productive synchronic phonological rule. [His result] contradicts the rule-based analyses of Otsu (1980) and Itô and Mester (1986)” (p. 163). The position taken by Timothy Vance, as seen by the quote above, seems close to this position (see e.g. Vance 1980a and Vance 1987, pp.146-148), although he does not explicitly deny the view that rendaku is phonological (see also Vance 2014a). Provided below is another quote from Vance (2014a):

> According to Okumura (1955), it is extremely difficult to specify when rendaku occurs, although there are certain tendencies. This candid assessment could perhaps be improved slightly by replacing the words ‘extremely difficult’ with the word ‘impossible’; certainly nothing in the half century of subsequent research on rendaku suggests that Okumura was overly pessimistic (pp.139-140).

The current paper can be understood as a constructive response to such a lexicalist view of rendaku.[3] Can we not be too “pessimistic” to throw rendaku away out of the domain of phonology entirely?

[3]This is not to say that the theoretical literature entirely ignored the irregular aspect of rendaku. 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/...show uniform voicing” (see also Ito & Mester 2003b). Note also that Vance (2014a) ultimately concludes, as with this paper, rendaku has a “rule-like” aspect.

2.2 Why do we care?

Why should we care? There are two important reasons. One is that rendaku and its properties have been used to argue for many theoretical apparatuses in the phonological literature.[4] This means that these theoretical claims will lose their empirical ground if rendaku is not phonological at all.

The second reason is that rendaku appears often 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). One danger is that those who read these textbooks, if they do not know Japanese well, may think that rendaku is a regular exception-less pattern, which is not the case (see again (1)).[5]

To flesh out the first point in more detail, what made rendaku famous among theoretical phonologists was the work by Otsu (1980), and its reanalysis by Ito & Mester (1986) which appeared in *Linguistic Inquiry*. These and their subsequent works have identified the five important properties of rendaku, listed in (2), which had significant theoretical ramifications.

(2) Rendaku is...
   a. a voicing process.
   b. blocked when there is another voiced obstruent within the same morpheme (=Lyman's Law).
   c. not blocked by [+voice] in sonorants.
   d. blocked when the second element is a left branch constituent of a compound (=Right Branch Condition)
   e. opaque with respect to velar nasalization—it overapplies despite velar nasalization.

These properties have been used to argue for the following theoretical apparatuses, summarized in (3)-(7):

(3) As a voicing process, rendaku is:
   a. an autosegmental spreading rule (Ito & Mester, 1986).
   b. a morphologized version of an intervocalic voicing process (Ito & Mester, 1996).
   c. a reflection of a universal morpheme realization requirement (Ito & Mester, 2003a).

(4) Lyman's Law is evidence for:

[4]The theoretical analyses of rendaku and related issues in the generative tradition include the following: Alderete (1997); Haraguchi (2001); Ito & Mester (1986, 1995, 1996, 1997, 1999, 2003a,b); Kuroda (1963, 2002); Kawahara (2012); Kawahara & Sano (2014b); Kurisu (2007); Mester & Ito (1989); Nishimura (2013, 2014); Otsu (1980); Rice (1993, 2005); Rosen (2003); Suzuki (1995, 1998); Zamma (2005), and more.

[5]Personally I have met a few non-Japanese linguists who misunderstood rendaku this way. During a conversation with one of them, I was told that he felt troubled when a student of his brought to him some forms that do not undergo rendaku.

a. a deletion rule of a floating feature (Ito & Mester, 1986).

b. OCP(+voice) (Ito & Mester, 1986).

c. self local-conjunction of constraints, particularly that of *VOICEDOBS (Ito & Mester, 2003a).

(5) Sonorant voicing is ignored by Lyman's Law because:

a. it is underspecified (Ito & Mester, 1986).

b. sonorants do not bear voicing feature at all (Mester & Ito, 1989).

c. obstruent voicing and sonorant voicing are different features (Rice, 1993).

(6) Right Branch Condition arises because:

a. phonology is sensitive to c-command (Otsu, 1980).

b. morpheme concatenation applies cyclically (Ito & Mester, 1986).

c. different morphological branching results in different prosodification (Ito & Mester, 2003a).

(7) The opaque interaction between rendaku and Lyman's Law is evidence for:

a. Sympathy Theory (Ito & Mester, 1997).

b. the distinction between lexical phonology and post-lexical phonology in Optimality Theory (Ito & Mester, 2003b).

It is not crucial here how convincing each argument is. More important is the simple fact that rendaku and its related properties have been used for phonological argumentation extensively, and rendaku has been made famous among the field of phonological theory in general.

To reiterate, the intention of this paper is not to deny the use of rendaku in phonological argumentation. Quite the contrary, in the face of lexical irregularity, and other general concerns discussed in section 1.2, this paper is proposing that we should examine more carefully whether we can use rendaku for phonological argumentation more carefully and explicitly. This is what we turn to now.

3 Experimental evidence that rendaku is phonological

Now we move on to reasons to think that rendaku is indeed phonological, or better put, rendaku has a phonological aspect. We can get rid of two concerns raised in section 1.2 quite easily; nobody perhaps would argue that rendaku is a matter of phonetic implementation, largely because rendaku happens at the time of compound formation.[6] Few people would argue that there are only a small

[6]The assumption here is that processes that occur at the morphological level is not a matter of phonetic implementation, which itself is based on the assumption that morphological information is not accessible to phonetic implemen-

number of examples for rendaku, unlike the case of mimetic palatalization, because there are in fact many examples undergoing rendaku (for example, see Ito & Mester 2003a and Irwin & Miyashita 2013).

The most thorny issue is therefore its productivity. In addition, some independent evidence that rendaku is phonological would be desirable. We will address these issues in the next two sections.

3.1 Experimental evidence I: The behavior of nonce words

Many experiments have tested aspects of rendaku, using nonce words (see Kawahara to appear for an overview). Some of the studies have used a forced-choice wug test (Kawahara & Sano, 2014b), whereas other studies have used a production study (Nakamura & Vance, 2002) or a naturalness rating study (Kawahara, 2012). Based on these experiments, there are reasons to think that rendaku applies to nonce words, often enough to think that it is at least partly productive.

For example, in the most recent two-way forced-choice format wug-test on rendaku (Kawahara & Sano, to appear), nonce words underwent rendaku about 60% of the time, when they do not violate Lyman's Law. If rendaku did not have a productive aspect to it, we would not expect rendaku to apply to nonce words at all. Inspecting their graph, the error bar does not even overlap with 50%, which means that rendaku applies to nonce words more often than the chance frequency.

In naturalness judgment experiments reported in Kawahara (2012), which used 5-point scale from "very unnatural (=1)" to "very natural (=5)" , nonce words that underwent rendaku were scored on average 3.42 in Experiment 1 (in which the participants were told that the stimuli were old native words) and 3.35 in Experiment II (in which the participants were told to treat the stimuli as nonce words). Rendaku applying to nonce words is therefore not judged to be unnatural.[7]

Another point to note is that in both types of experiments, the effect of Lyman's Law is clear. In the wug test experiments, those nonce words that violate Lyman's Law undergo rendaku less likely than those nonce words that do not (Ihara et al., 2009; Kawahara & Sano, to appear; Vance, 1979, 1980b). Also rendaku is rated less naturally when it violates Lyman's Law than it is not (Kawahara, 2012). As Vance (2014a) puts it, then: "Does it make sense to say that there is a

tation rules. Although this assumption is a standard one (Chomsky & Halle, 1968; Cohn, 2007; Pesetsky, 1979; Levelt et al., 1999), there are some works that argue that some morphological information is accessible to phonetics (Bird, 2004; Cho, 2001; Ernestus & Baayen, 2006; Lee-Kim et al., 2013; Steriade, 2000). No work as far as I know has attempted to characterize rendaku as a matter of phonetic implementation, however, perhaps because even syntactic information—such as a difference between arguments and adjuncts—can influence the applicability of rendaku (Kozman, 1998; Sugioka, 2002, 2005; Vance, 1987, 2014a,b). No phonetic works have shown that rendaku instantiates a gradient change, like other phonetic implementation processes, either.

[7]Can the pattern of rendaku in nonce word experimentation be explained by analogy? The analogical analysis by Ohno (2000) is not developed enough to make solid predictions about nonce words. Ohno (2000: 162) says "If there is no possible reference to existing rendaku forms, the item does not undergo rendaku in a novel compound", which would probably not predict 60% of rendaku application percentages for nonce words, especially because these speakers were explicitly instructed to treat the stimuli as nonce words—words that do not exist.

constraint [=Lyman's Law] on something (i.e., *rendaku*) that is not itself a rule?" (p. 143). At the very least, rendaku's behavior in nonce word experimentation (i) is systematic in that it is sensitive to Lyman's Law, and (ii) can be argued to be phonological, to the extent that Lyman's Law can be independently characterized as a phonological principle such as OCP(voice) (Ito & Mester, 1986).

The second argument should perhaps be taken with caution, because dissimilation in voicing—or OCP(voice)—is rare cross-linguistically, and such rare existing cases of voicing dissimilation historically arose from dissimilation in other phonological contrasts (Kawahara, 2008; Ohala, 1981, 1993). However, Lyman's Law is active at least within the phonology of Japanese. Not only is it active in nonce word experimentation (Kawahara, 2012), it induced an emerging phenomenon of causing devoicing of geminates in Japanese loanwords (Nishimura, 2003; Kawahara, 2006, 2008, 2011b).

3.2 Experimental evidence II: Fukuda and Fukuda (1994)

Having observed that rendaku can apply to nonce words and that rendaku is subject to Lyman's Law in experimental settings with nonce words, there are some additional experimental evidence that rendaku has phonological aspects.

First, Fukuda & Fukuda (1994) built on the general observation that children with specific language impairment (SLI) fail to learn productive linguistic processes, whereas they can learn lexical information without obvious difficulties (Paradis & Gopnik, 1997). Fukuda & Fukuda conducted a word-formation task using children with SLI as a target group and children without SLI as a control group. The children with SLI applied rendaku to infrequent or novel compounds much less frequently than children without SLI. The fact that the SLI children had failed to learn to apply rendaku to unfamiliar compounds supports the idea that rendaku can be regarded as a productive phonological process. See also Kubozono (2005) for its more recent interpretation of this data.

In contrast, the SLI children generally showed rendaku in familiar compounds. This result indicates that some familiar compounds with rendaku are stored in memory. The overall results by Fukuda & Fukuda (1994) thus show that rendaku perhaps has both lexical and productive aspects. No phonologists who knows rendaku in some detail would argue that rendaku is purely phonological without any lexical influence—what is important is that rendaku *can be* produced by a productive component of the grammar.

3.3 Experimental evidence III: Kobayashi et al. (2013)

Second, Kobayashi et al. (2013) report an ERP-based neurolinguistic experiment that further supports the view of rendaku as rule-governed. They found that Japanese speakers show LAN and

P600—event related potentials that appear in response to particular types of linguistic stimuli—in response to rendaku-undergoing stimuli, using those items that do not usually show rendaku. LAN is independently known to appear as a result of over-application of regular rules (Weyerts et al., 1997), and P600 is also observed in response to similar stimuli (at least in some cases) (Morris & Holcomb, 2005). Therefore, their results support the rule-based nature of rendaku from the perspective of neurolinguistics; when rendaku applies to otherwise non-undergoing items, rendaku behaves much like regular rules in other languages.

4 Rendaku interacts with phonological constraints

In addition to the experimental evidence considered above, there are some additional reasons to think that rendaku is phonological. The arguments are based on the fact that rendaku is subject to phonological principles that are independently motivated on cross-linguistic grounds. We have already mentioned the behavior of Lyman's Law in nonce word experiments—we turn to other examples now.

4.1 Place markedness hierarchy

First, Ihara et al. (2011), cited and discussed in Kawahara (to appear), ran a wug-test to examine various segmental effects on rendaku, addressing which consonants are most likely to undergo rendaku. They found segmental effects of consonant with the following hierarchy: /h/ $>$ /k/ $=$ /t/ $>$ /s/, where /h/ is most likely to undergo rendaku and /s/ is least likely to undergo rendaku. This hierarchy can be interpreted as reflecting the cross-linguistically motivated markedness hierarchy, *[z] $\gg$ *[g], *[d] $\gg$ *[b][8]: this hierarchy is compatible with the cross-linguistic markedness patterns and phonetic challenges that voiced obstruents present.

Voiced fricatives seem cross-linguistically more marked than voiced stops, because voiced fricatives require high intraoral air pressure to cause frication, but at the same time the high intraoral air pressure makes it difficult to maintain airflow across the glottis (Ladefoged & Maddieson, 1996; Ohala, 1983). The rendaku hierarchy within voiced stops found in this experiment is also compatible with the cross-linguistic markedness scale and with the aerodynamic difficulty hierarchy among voiced stops with different place of articulation: the further back the oral occlusion is, the quicker the intraoral air pressure goes up, resulting in the cession of glottal airflow (Hayes, 1999; Hayes & Steriade, 2004; Ohala, 1983; Ohala & Riordan, 1979).

[8]This markedness hierarchy affected rendaku applicability in their experiment in a stochastic way; i.e. it is not the case, for example, that rendaku of [s] is categorically blocked. However, such stochastic phonological patterns are now well-attested (Boersma & Hayes, 2001; Hayes & Londe, 2006; Pierrehumbert, 2001; Zuraw, 2000), and do not need to be relegated to the phonetic component.

To the extent that these markedness hierarchy is motivated in the phonology of other languages (Hayes, 1999; Hayes & Steriade, 2004; Ohala, 1983), it seems reasonable to think that rendaku is phonological, because it interacts with a phonological markedness hierarchy.

4.2 Prohibition against the adjacent homorganic consonants

Another piece of evidence comes from a prohibition against a pair of place-homorganic consonants in adjacent syllables, again a restriction that is known to hold in many different languages, most famously in Semitic languages (Alderete & Frisch, 2007; Frisch, 2004; Frisch et al., 2004b; Greenberg, 1950; McCarthy, 1979). In Japanese, pharyngeal /h/ becomes labial /b/ after rendaku. Given this alternation, words of the form /hVmV/ do not undergo rendaku, whereas words of the form /hVnV/ do (Kawahara et al., 2006). This contrast is illustrated in (8) and (9).

(8) /hVmV/ words do not undergo rendaku
   a. /hama/ –/suna-**h**a**m**a/ ‘beach’
   b. /hamo/–/oo-**h**a**m**o/ ‘big hamo (fish name)’
   c. /hima/–/tema-**h**i**m**a/ ‘trouble’
   d. /hime/–/mai-**h**i**m**e/ ‘dancing princess’
   e. /himo/–/kutu-**h**i**m**o/ ‘shoe lace’
   f. /hema/–/oo-**h**e**m**a/ ‘big mistake’

(9) /hVnV/ words usually undergo rendaku
   a. /hana/–/ai-**b**a**n**a/ ‘Aibana (flower name)’
   b. /hane/–/te-**b**a**n**e/ ‘hand wing’
   c. /hina/–/nagasi-**b**i**n**a/ ‘floating doll’
   d. /huna/–/oo-**b**u**n**a/ ‘big gibel’
   e. /hune/–/oo**b**u**n**e/ ‘big ship’

This blockage of rendaku in (8) can be understood as avoidance of creating the surface [bVmV] configuration, which itself comes from avoidance of a pair of consonants that have the same place of articulation in adjacent syllables (here a prohibition against two adjacent labials). To the extent that this restriction is motivated phonologically in other languages, again the blockage of rendaku in (8) constitutes evidence that rendaku has something to do with phonology.

4.3 *NC and *VoiceObsGem

Similar arguments can be made based on the effect of other well-known phonological restrictions found in Japanese and elsewhere (p.c. Anonymous). First, rendaku is more likely when the first

element ends with a moraic nasal (e.g. /heeban-**g**ata/ 'flat accent') than when it ends with a vowel (Labrune, 2012). This encouragement of rendaku after a nasal consonant can be understood as post-nasal voicing, a process that is well-attested cross-linguistically (Pater, 1999). Second, rendaku never co-occurs with gemination (e.g. /i**k-k**ai/ 'first floor'; cf. /sa**n-g**ai/ 'third floor'). This blockage of rendaku can be understood as rendaku interacting with a prohibition against voiced obstruent geminates (Kawahara, 2006). Yet again, the interaction of rendaku with these phonological constraints would lead us to suspect that rendaku is phonological.

4.4 Identity Avoidance

Finally, Kawahara & Sano (2014b) have recently identified a yet another phonological factor that interacts with rendaku, namely, avoidance of two adjacent identical CV moras (i.e. Identity Avoidance). Their experiment showed that rendaku is more likely to apply when the two CV moras across a morpheme boundary are identical (e.g. [i**ka+ka**niro]) than when they were not (e.g. [i**ka+ta**niro]); i.e., the Identity Avoidance constraint increases the applicability rendaku, or Japanese speakers make use of rendaku to satisfy the Identity Avoidance constraint.

The experiment also showed that rendaku is less likely to apply when it would result in two adjacent identical CV moras across a morpheme boundary (e.g. [i**ga+ga**niro]) than when it would not (e.g. [i**ga+da**niro]). The Identity Avoidance constraint decreases the applicability of rendaku.

To the extent that Identity Avoidance is a phonological constraint (Yip, 1998), rendaku should at least partly be treated as phonological. The dual nature of Identity Avoidance is also interesting—it is a classic observation about phonological constraints that they can both trigger and block phonological processes—the observation known as "conspiracy" (Kawahara, 2012; Kisseberth, 1970; McCarthy, 2002; Yip, 1988). Identity Avoidance interacts with rendaku in such a way that it shows characteristics of typical phonological constraints. This observation, then, is perhaps a good reason to suspect that rendaku can be treated as phonological.

What makes the results by Kawahara & Sano (2014b) even more interesting is the fact that in the existing patterns of rendaku based on a corpus study, there is no such effects of Identity Avoidance on rendaku. Irwin (2014) shows, based on the rendaku database (Irwin & Miyashita, 2013), that rendaku application is not blocked by adjacent identical moras in any substantial way in the contemporary Japanese lexicon. The effect of Identity Avoidance in this experiment is therefore "emergent" in experimental settings—-rendaku invites that grammatical effect to emerge.

5 Orthographic explanations of rendaku and Lyman's Law

The previous section has surveyed arguments that rendaku is phonological, or at least rendaku has phonological aspects. This section addresses one important aspect of rendaku, which any theory

of rendaku should bear in mind; namely, the effect of orthography.

As noted by Vance (to appear), rendaku is not simply a matter of "voicing of initial consonants", but instead involves more complicated parings of sounds when viewed at the phonetic level. The surface phonetic pairs that are related by rendaku are shown in (10). 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.

(10) Paring of sounds related by rendaku

a. [ɸ]–[b] (e.g. [ɸue]–[bue] 'flute')

b. [ç]–[b] (e.g. [çi]–[bi] 'fire')

c. [h]–[b] (e.g. [ha]–[ba] 'tooth')

d. [t]–[d] (e.g. [ta]–[da] 'field')

e. [ts]–[z] (e.g. [tsuma]–[zuma] 'wife')

f. [tɕ]-[ʑ] (e.g. [tɕikara]–[ʑikara] 'power')

g. [k]–[g] (e.g. [ki]–[gi] 'tree')

h. [s]–[z] (e.g. [sora]–[zora] 'sky')

i. [ɕ]–[ʑ] (e.g. [ɕima]–[ʑima] 'island')

Among those, (d, g, h, i) are straightforward minimal pairs of sounds that differ in voicing, but the others are not. Of course this complexity is not insurmountable; for example, for (a-c), it is possible to posit underlying /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].[9] The deaffrication in (e, f) is also expected as a result of independently motivated allophonic changes, where affricates are often realized as fricatives intervocalically (Maekawa, 2010)—and rendaku usually occurs in intervocalic contexts.

Although it is not impossible—or even not undesirable—to construct a phonological analysis of the complicated patterns in (10) in this way, it is of some importance to note that from the view point of orthography, all the pairings in (10) can be treated as an addition of the same diacritic mark (*dakuten*) (Vance, to appear). All the letters for the sounds that appear on the right in (10) 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* marker".

Treating rendaku as a matter of orthography appears to come with additional virtues. Recall that Lyman's Law—the blockage of rendaku by a voiced obstruent—ignores voicing in sonorants, and several theoretical apparatuses were proposed to account for that observation (=(5)). From

[9]Positing underlying /p/ for surface /h/ is historically speaking correct (Takayama, to appear), but it faces some challenges when viewed synchronically (Fukazawa et al., 2002; Labrune, 2012; Shibatani, 1990).

the viewpoint of orthography, however, there is a simple explanation: Japanese orthography marks voicing on obstruents with a diacritic (*dakuten*), but not on sonorants. Therefore, Lyman's Law can also be understood as a prohibition against two dakuten diacritics.

There is independent reason to suspect that Lyman's Law may be a matter of letter configurations, rather than sound configuration. In the loanword phonology of Japanese, geminates can devoice when they co-occur with a voiced obstruent (e.g. **/be*dd*o/** → **/be*tt*o/** 'bed') (Nishimura, 2003), 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'; /kyuu**p**i**dd**o/ → /kyuu**p**i**tt**o/ 'cupid'). This observation raises the possibility that this devoicing occurs because /p/ also has a diacritic mark in the Japanese orthographic system (*han-dakuten*). It is then very straightforward to say that Lyman's Law prohibits two diacritics within a morpheme. (Though see Fukazawa et al. 2014 for a phonological analysis which does not rely on the orthography.)

Given these considerations, should we say that rendaku and Lyman's Law are purely orthographic? Perhaps not quite. First, rendaku appeared in the history of Japanese well before Japanese people started using the diacritic mark for voiced obstruents (Takayama, to appear). Therefore, rendaku could not have raised as a matter of letters (this argument should perhaps be taken with a grain of salt because contemporary Japanese speakers may treat rendaku as an orthographic process, regardless of its historical origin).

Second, children start acquiring rendaku well before they start learning letters (Sugimoto, 2013), which cannot be explained if rendaku is purely a matter of letters. Third, Kawahara & Sano (2014a) found that Japanese speakers avoid creating identical consonants in adjacent syllables by way of rendaku (e.g. */i**ga+go**moke/ from /i**ga**/+/**ko**moke/). The consonantal identity effect cannot be reduced to an orthographic matter, because, for example, /ga/ and /go/ do not share the same letter in Japanese. Moreoever, the view that rendaku is purely a matter of orthography has a hard time explaining the evidence discussed in sections 3 and 4: why would purely orthographic processes be sensitive to phonological conditions and show features of regular rules in experimentation?

Finally, I was also informed (p.c. Anonymous) that when their child learned rendaku, he overapplied rendaku almost to every lexical item before he learned orthography, which is also indicative that rendaku is acquired as a productive phonological rule (see also Fukuda & Fukuda 1994) independent of the orthographic knowledge. A more systematic longitudinal acquisition is certainly hoped for, not only to address this specific issue about the influence of orthography, but also to address the general issue of whether rendaku is grammatical or not.

At any rate, this issue—to what extent rendaku and Lyman's Law should be characterized as orthographic—should continued to be discussed. Phonologists should not simply ignore orthographic factors away.

6 Conclusion

Ultimately, it seems most constructive to admit that rendaku both has lexical and phonological aspects, with possible influence from non-grammatical factors such as orthography. The theory of rendaku and related issues should attempt to delineate these various factors, and construct a comprehensive analysis of rendaku, by looking at both grammatical and lexical aspects of rendaku. The time is ripe for this enterprise, given that theories of lexical exceptions and variations have flourished in recent years (Anttila, 2002; Coetzee & Kawahara, 2013; Coetzee & Pater, 2011; Inkelas, 2011; Pater, 2000, 2010; Zuraw, 2000).

The conclusion that rendaku has both lexical and phonological natures is not that interesting or surprising in and of itself for most phonologists that know rendaku well (Ito & Mester, 2003b; Kubozono, 2005; Vance, 2014a). What is important is that we carefully consider non-phonological factors when we construct phonological analyses (de Lacy, 2009).

In summary, the question that this paper raised was: Can we use rendaku for phonological argumentation? The answer that this paper proposed is "yes".[10] This answer may not come as a surprise for many practicing phonologists. However, the message that this paper wanted to raise in this paper goes beyond this simple question-and-answer: it is important to examine the quality of phonological data with explicit discussion (de Lacy, 2009, 2014), and this paper is a concrete exercise of this practice.

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[10] Ultimately, even if the arguments presented in this paper do not go through, this paper does not lose its value, as long as the importance of the discussion of the quality of phonological data is appreciated.

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