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CHAPTER 3

Psycholinguistic studies of rendaku

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This paper provides a comprehensive overview of previous experimental studies on rendaku. Some major questions that have been addressed in this body of work include: (1) is rendaku grammatical or lexicalized? (2) are specific aspects of rendaku, such as the Right-Branch Condition, psychologically real in the minds of contemporary speakers of Japanese? (3) how does Lyman's Law interact with rendaku in experimental settings? and (4) are there any aspects of rendaku that emerge in experimental settings even though they are not observed as existing patterns in the lexicon? After the review of studies addressing these issues, the paper concludes with a number of remaining questions which should be addressed in future experimental studies of rendaku.

3.1 Outline

This paper provides an overview of experimental studies of rendaku. The general spirit of these studies is to test whether rendaku and the factors that appear to affect its applicability are psychologically real. Experiments using nonce words and those that ask the participants to create new compounds address the question of whether patterns of rendaku are internalized in native speakers' minds, i.e., grammaticalized. This spirit is clearly articulated in the first experimental study of rendaku (Vance 1979).

In §3.2, experiments that address the question of whether rendaku is a grammatical process or a lexicalized pattern are introduced. Next, §3.3 summarizes experiments on various specific aspects of rendaku, and then §3.4 discusses experimental approaches to Lyman's Law (VANCE:§1.4), as it relates to rendaku and beyond. Some remaining issues are taken up in §3.5. Experimental approaches are also central to research on the acquisition of rendaku, both by children learning Japanese natively and by students learning Japanese as a foreign language, but

research on the acquisition of *rendaku* has begun only recently (including the paper in this book by NAKAZAWA ET AL. P5).

3.2 Grammatical versus Lexical

One of the most important questions about *rendaku* is whether it is a productive, phonological process or a lexicalized, analogical pattern (Vance 2014b; Kawahara 2015a). The first position assumes or asserts that *rendaku* is governed by the phonological component of grammar, and this is the position taken by most generative studies of *rendaku* (e.g., McCawley 1968: 86–87; Otsu 1980; Ito & Mester 1986, 1995b: 819, 2003a: ch.4, 2003b; Mester & Ito 1989: 277–279; Kuroda 2002; Kurisu 2007; see also KAWAHARA & ZAMMA: §2.5.2). On this view, *rendaku* is subject to phonological analysis and can bear on phonological theorizing. The other view is that *rendaku* is lexical, not governed by a productive linguistic system; whether a particular existing compound shows *rendaku* or not is stored in memory for each compound, and whether *rendaku* applies or not to novel compounds is determined by lexical analogy, via either phonological or semantic similarity. On this view, analyses of *rendaku* should not bear on phonological issues.

One experimental study that addresses this question (Ohno 2000) argues for the lexicalist view of *rendaku*. Among the second elements used in the experiment were *kami~gami* 髮 ‘hair’, which almost always undergoes *rendaku* ([+*rendaku*]), and *ti~zi* 血 ‘blood’, which almost never does ([–*rendaku*]). The test was a two-way forced choice “wug” test (Berko 1958) involving real elements in novel combinations, that is, compounds that are not established in the contemporary Tokyo Japanese vocabulary. The results showed that the [+*rendaku*] item generally did not undergo *rendaku* in one case (*siro+kami* ‘white hair’, written ⟨白髮⟩), whereas the [–*rendaku*] item generally did undergo *rendaku* in one case (*mimi+zi* ‘ear bleeding’, written ⟨耳血⟩). OHNO (2000: 163) thus concludes that *rendaku* application is determined by lexical analogy to existing compounds (cf. *kuro+kami* 黒髮 ‘black hair’ and *hana+zi* 鼻血 ‘nosebleed’), and that characterization of each lexical item in terms of a grammatical feature (i.e., [±*rendaku*]) does not capture the results very well.

Another experiment approached the same issue from a different perspective (Fukuda & Fukuda 1999). Children with specific language impairment (SLI) are known to fail to learn linguistic processes, whereas lexical information can be learned without obvious difficulties (Paradis & Gopnik 1997). Fukuda and Fukuda built on this observation and conducted a word-formation experiment 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

often than children without SLI. The fact that the SLI children had not learned to apply rendaku to unfamiliar compounds supports the idea that rendaku is a productive phonological process. 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 thus show that rendaku perhaps has a dual nature, that is, it may be both lexical and productive (Kubozono 2005:5–7; cf. Pinker & Prince 1998; Clahsen 1999; Pinker 1999 for theories of morphology with such dual mechanisms).

Finally, Kobayashi et al. (2013, 2014) report an ERP-based neurolinguistic experiment that supports the view of rendaku as rule-governed. ERP (Event-Related Potentials) are neurological responses that are detected in response to stimuli, and previous studies have shown that different kinds of ERP responses are observed in response to different kinds of linguistic stimuli. Kobayashi et al. found that Japanese speakers show LAN and P600 in response to rendaku in elements that do not usually show rendaku (e.g., *hime* 姫 ‘princess’ and *tomo* 友 ‘friend’). LAN is independently known to appear as a result of over-application of regular rules to exceptional items (Weyerts et al. 1997), and P600 is observed in similar responses (at least in some cases) (Morris & Holcomb 2005). These results therefore support the rule-based nature of rendaku: when it is applied to exceptional items, it behaves like regular rules in other languages.

3.3 Experiments on specific aspects of rendaku

As explained elsewhere in this book, there are many factors that either increase or decrease the applicability of rendaku. This section discusses various studies that examine such factors experimentally.

3.3.1 Lexical stratification and rendaku

Rendaku is much more likely to apply to native or native-like elements than to elements from other strata (Otsu 1980:208–210; Ito & Mester 1995b:823, 2003a:148; 2008:85–86). Suzuki et al. (2000) addressed the question of whether this restriction is productive. A larger question they attempted to address is whether the stratification of the Japanese lexicon (Ito & Mester 1995b, 1999, 2008) is itself psychologically real. For other experiments addressing this larger question of the psychological reality of lexical stratification, see Moreton & Amano (1999), Gelbart (2005), Gelbart & Kawahara (2007), and Tanaka & Yashima (2013).

One of the Suzuki et al. experiments compared nonce words that phonotactically could be native words with those that could not be, where non-native

status was cued by a voiceless stop immediately following a nasal – a violation of *NT (Ito & Mester 1995b: 819–820, 1999: 66, 2008: 86,88,101) – or a singleton /p/ (i.e., non-geminate /p/) – a violation of *[p] (Ito & Mester 1995b: 819–820, 1999: 66). The results showed no differences between the two conditions, which led Suzuki et al. to dispute the psychological reality of the effect of lexical stratification on rendaku.

One problem with this interpretation of the results is that nonce words that phonotactically could be native could also belong to any other stratum (Fukazawa et al. 2002; Ota 2004). Given a core-periphery structure of the Japanese lexicon (Ito & Mester 1995b, 1999, 2008), an element of a subset (the native stratum) can also be a member of a superset (e.g., the recent loan stratum). That is, there is no guarantee that the “nonce Yamato words” that Suzuki et al. (2000) used were perceived as native words. Even if a core-periphery structure does not hold strictly (Kawahara et al. 2002), it is generally the case that an item that is phonotactically appropriate as a native word could also be a recent loan, because recent loans are not subject to any phonotactic constraints that are specific to them (with the possible exception of the rarity of /ry/: Moreton & Amano 1999; Moreton, Amano & Kondo 1998: 67). In fact, nonce words may tend to be perceived as recent loans regardless of phonotactics, because words that speakers do not already know are likely to be “foreign” (i.e., recent loanwords). There is also some additional evidence that nonce words and recent loans are treated alike, at least in Japanese. First, nonce words tend to have the same accentual patterns as loanwords (Katayama 1998: 184; Kawahara & Kao 2012: 845–846; Kawahara 2015b: 481–482). Second, both nonce words and loanwords are typically written in *katakana* (Kawahara 2012: 1198).

3.3.2 Effects of E1

It is generally assumed in the theoretical literature that E1 (i.e., the first element of a two-element compound) has little or no effect on the applicability of rendaku, although Rosen’s Rule (Vance 2015b; IRWIN $\mathbb{P}7$) and the strong version of Lyman’s Law (VANCE & ASAI: §8.3.2) are exceptions to this generalization. However, Tamaoka et al. (2009), extending work by Murata (1984) and Ihara and Murata (2006), identified some effects of E1 via experimentation. The first observation in the Tamaoka et al. study was that the shorter E1 is, the more likely it is that rendaku will apply to E2 (i.e., the second element of a two-element compound). The distinction between one-mora elements and longer elements seems especially clear. They also found that the etymological status (or vocabulary stratum) of E1 affects the applicability of rendaku according to the following hierarchy: native > Sino-Japanese > recent loan. It may be that the etymological status of E1 affected

the interpretation of the etymological status of the whole compounds used as test items, resulting in the observed hierarchy. The experiment also found that an E1 ending with the moraic nasal /N/ is more likely to trigger rendaku than an E1 ending with a vowel. This result replicates a putative lexical tendency concerning rendaku (but see VANCE & ASAI: §8.3.1).

In another study, Tamaoka and Ikeda (2010) compared the effects of five different E1s (*imo* 芋 ‘potato’, *kome* 米 ‘rice’, *soba* 蕎麦 ‘buckwheat’, *mugi* 麦 ‘barley’, *kokutoo* 黒糖 ‘black sugar’) on rendaku with a fixed E2 (*syootyuu* 焼酎 ‘*shōchū* distilled spirits’). They tested speakers from six different regions (Kagoshima, Ōita, Fukuoka, Yamaguchi, Hiroshima, and Shizuoka) which differ in familiarity with these different kinds of *shōchū*. The purpose of this design was to test the hypothesis that familiar non-native items can undergo rendaku, when they are, in a sense, “Japan-ized” (Otsu 1980: 209–210; Ohno 2000: 157–158; Ito & Mester 2003a: 149–151, 2008: 90; Takayama 2005). If familiarity facilitates rendaku, the speakers from different regions should differ as to which E1 induces rendaku the most in the Sino-Japanese binom *syootyuu*.¹ The prediction is that the compound denoting the most familiar type of *shōchū* in each region will undergo rendaku most often. However, the results showed no substantial differences among regions. In terms of the number of responses with rendaku, the ranking of the five different E1s (from highest to lowest) was: *imo* > *kome* ≥ *soba* > *mugi* > *kokutoo*. There was an effect of E1 length: the shorter the E1, the more likely rendaku was, with four-mora *kokutoo* ranked last. The presence of a voiced stop (in *soba* and *mugi*) may have inhibited rendaku to some extent, although the Tamaoka and Ikeda (2010: 75) doubt that the strong version of Lyman’s Law is active.

In both of the two experiments described just above, the length of E1 had an effect on rendaku, but neither was designed to test the length effects predicted by Rosen’s Rule. According to the first sub-case of Rosen’s Rule, rendaku is more likely to apply when E1 is longer than two moras. Kawahara and Sano (2014c) addressed whether this pattern in the existing lexicon can be replicated using nonce words. The results of their experiment showed a small trend in the predicted direction, with rendaku occurring more frequently when E1 was three moras than when it was two moras, but the difference is not statistically significant. Sano and Kawahara conclude that the lexical tendency represented by first sub-case of Rosen’s Rule may not be grammaticalized.

Kawahara and Sano (2014b) investigated another factor that appears to impact the applicability of rendaku, namely, identity avoidance, that is, avoidance of two

1. The term *Sino-Japanese binom* denotes a prototypical Sino-Japanese vocabulary item, written with two *kanji* (i.e., Chinese characters). See VANCE & ASAI (§8.1.1).

adjacent identical CV moras. The effect of identity avoidance is known to play a role in some domains of Japanese phonology (Sano 2013). Its possible effect on *rendaku* is briefly noted by Satō (1989:256) but denied by Irwin (2014) on the basis of statistical evidence from the *Rendaku Database* (IRWIN $\mathbb{P}6$). The Kawahara and Sano (2014b) experiment showed that participants were more likely to apply *rendaku* when two CV moras straddling the morpheme boundary in a nonce compound would be identical without *rendaku*, as in *ika+kaniro*, and less likely to apply *rendaku* when the two moras would not be identical, as in *ika+taniro*. That is, identity avoidance appears to promote *rendaku* and make *ika+ganiro* more likely than *ika+daniro*. The experiment also showed that participants were less likely to apply *rendaku* when it would result in two identical CV moras straddling the morpheme boundary. For example, the participants were significantly more likely to choose *iga+daniro* over *iga+taniro* than they were to choose *iga+ganiro* over *iga+kaniro*. In this case, it appears that identity avoidance inhibits *rendaku*.

A follow-up experiment reported in KAWAHARA AND SANO ($\mathbb{P}4$) shows that in addition to a moraic identity effect, *rendaku* is also inhibited by a consonantal identity avoidance effect. For example, *iga+komoke* is less likely to undergo *rendaku* than *iga+somoke*.

3.3.3 The Right-Branch Condition

The Right-Branch Condition (KAWAHARA & ZAMMA: §2.4) is the widely known but controversial constraint first proposed by Otsu (1980). The claim is that *rendaku* can apply only to an element that is on a right branch in the constituent structure of a compound. Kozman (1998) tested the psychological reality of this restriction by asking native Japanese speakers to guess the meanings of novel compounds in a two-way forced choice format. For example, each participant heard either *nuri+basi+bako* or *nuri+hasi+bako* (cf. the verb *nur-u* 塗る ‘lacquer’ and the nouns *hasi~basi* 箸 ‘chopsticks’ and *hako~bako* 箱 ‘box’) and was asked to choose between a meaning corresponding to $\{A\{BC\}\}$ (‘lacquered case for chopsticks’) and a meaning corresponding to $\{AB\{C\}\}$ (‘case for lacquered chopsticks’). The meanings were cued by full sentences. The Right-Branch Condition predicts that if the second element (*hako~bako*) shows *rendaku*, it should be interpreted as being on a right branch. That is, *nuri+basi+bako* should be interpreted as having the constituent structure $\{AB\{C\}\}$. However, the results did not indicate that speakers use the presence versus absence of *rendaku* on the middle element to disambiguate the meanings of such compounds.

Ihara and Murata (2006), on the other hand, found some evidence for the Right-Branch Condition in a forced choice test, although the cues presented to the participants may have been too short for non-linguists to disambiguate the

meanings (Kumagai 2009). The most recent experiment by Kumagai (2014) shows a mixed result for the psychological reality of the Right-Branch Condition. The most recent reanalysis of Kumagai's data, based on a signal detection analysis (Macmillan & Creelman 2005) and reported in Kumagai (2014), in fact shows that there is much inter-speaker variability: some speakers are sensitive to the Right-Branch Condition, but most speakers are not.

3.3.4 Semantic relationships between E1 and E2

Kozman (1998) also tested another putative restriction on rendaku, this one involving N+V=N compounds. The claim is that rendaku applies if E1 (a noun) is semantically a “modifier” of the verb from which E2 is derived but does not apply if E1 is semantically the direct object of that verb. Participants in the experiment heard novel compounds, some with rendaku and some without, and were asked to choose a definition for each. For example, some participants heard *eda+haki* and others heard *eda+baki* (cf. *eda* 枝 ‘branch’, *hak-u* 掃く ‘sweep’), and the hypothesis was that the form with rendaku would be more likely to induce the modifier interpretation (i.e., ‘sweeping with a branch’), while the form without rendaku would be more likely to induce the direct-object interpretation (i.e., ‘sweeping away branches’). However, the results did not show that the presence of rendaku encouraged the modifier interpretation of E1.

On the other hand, Nakamura and Vance (2002), cited and discussed in Vance (2014: 143–149), conducted a production study to address the same issue. They presented sentential prompts with two conditions: (1) sentences showing that E1 is an object of E2 (e.g., *kutu o hosu* 靴を干す ‘to dry shoes’) and (2) sentences showing that E1 is a modifier of E2 (e.g., *yoru hosu* 夜干す ‘to dry at night’) (Vance 2014b: 146). The participants were asked to produce compounds based on these sentential prompts. The experiment found, as expected from the lexical pattern but contrary to what was found by Kozman (1998), that Japanese speakers produced less rendaku when the prompt involved E1 as a direct object.

3.3.5 Segmental effects

Ihara, Tamaoka, and Lim (2011) ran a “wug” test to examine which consonants are most likely to undergo rendaku. Their results follow the hierarchy /h/ > /k/ = /t/ > /s/, that is, /h/ was most likely and /s/ was least likely to undergo rendaku. They argue that this hierarchy can be interpreted as reflecting the markedness hierarchy $*[z] \gg *[g], *[d] \gg *[b]$ (where “*[X]” is an OT constraint prohibiting the segment [X]), and that 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 friction, but at the same time the high intraoral air pressure makes it difficult to maintain airflow across the glottis (Ohala 1983; Hayes & Steriade 2004: 7–8). The hierarchy found in this experiment, namely, /b/ > /g/ = /d/ (the rendaku partners of /h/, /k/, and /t/), is also compatible 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 builds up, resulting in the cessation of glottal airflow (Ohala & Riordan 1979; Ohala 1983: 196–199; Hayes & Steriade 2004: 8–13).

3.4 Experiments on Lyman's Law

There have been a number of experiments on Lyman's Law, some involving rendaku and some going beyond. Lyman's Law says that rendaku is blocked when E2 already contains a voiced obstruent (VANCE: §1.4). Vance (1980b), reporting the results of earlier work (Vance 1979), presents a "wug" experiment designed to test the effect of Lyman's Law on rendaku. The results showed large inter-speaker variability, but all participants applied rendaku less often if it resulted in a violation of Lyman's Law. Some evidence of a locality effect was also found: the closer the voiced obstruent in E2 was to the potential rendaku site, the less likely rendaku was to occur. This is an interesting result because, since Lyman's Law holds almost without exception in the Japanese lexicon (VANCE: §1.4; VANCE & ASAI: §8.1.1), the observed locality effect is not based on a lexical pattern.

Ihara et al. (2009) also investigated whether the location of a voiced obstruent in E2 affects the applicability of rendaku, and they found that locality did matter: the closer the voiced obstruent was to the potential rendaku site, the less likely E2 was to undergo rendaku. They conducted the same experiment twice, once in 1984 and again in 2005, and this locality effect was weaker in the 2005 results than in the 1984 results.

Kawahara (2012) reports naturalness judgment experiments on the effect of Lyman's Law on rendaku. Native speakers of Japanese were presented with E1 (always *nise* 偽 'fake'), E2, and the compound E1+E2 with rendaku. They were asked to rate how natural the form with rendaku is for each compound, using a 5-point Likert scale. The participants judged rendaku that violates Lyman's Law less natural than rendaku that does not. In this experiment, the location of the medial voiced obstruent in E2 in the Lyman's Law violations did not matter, and the conjecture was that the locality effect has been diminishing over time so that it had no discernible effect by the time the experiment was run in 2011. In an

experiment conducted in 2013, Kawahara and Sano (2014a) also found no locality effect, which could be taken as support for this conjecture.

Kawahara and Sano (2014a), building on Kawahara and Sano (2014b), used a “wug” test to investigate whether the simultaneous violation of an identity avoidance constraint and Lyman’s Law (e.g., an E2 of the form *dadanu*) is considered worse than a violation of Lyman’s Law alone (e.g., an E2 of the form *daguta*). They found that as long as the violation occurs in adjacent syllables, Japanese speakers do avoid simultaneous violation more strongly. Since there are only a handful of exceptions of Lyman’s Law in the Japanese lexicon, they argue that this finding cannot be reduced to an inference based on a lexical pattern.

Kawahara and Sano (2014c) tested the “strong version” of Lyman’s Law (see §3.3.2 above), according to which rendaku is blocked by a voiced obstruent in either E2 or E1. Although the strong version seems to have held in 8th-century Old Japanese, a voiced obstruent in E1 seems to have at most a marginal inhibiting effect synchronically (Sugitō 1965; Ito & Mester 2003a: 108–111). Sano and Kawahara, using a “wug” test, did not find a significant inhibiting effect.

Incidentally, in the Fukuda and Fukuda (1999) experiment described above in §3.2, there was no evident difference between the SLI group and the control group with respect to Lyman’s Law. Both groups of participants showed unexpectedly high rates of rendaku in cases where rendaku resulted in a Lyman’s Law violation, suggesting that neither group had learned Lyman’s Law. Kawahara (2008: 324–326), expanding upon the theory of dissimilation by Ohala (1993: 253–254), argues that Lyman’s Law may not be a natural, innate, universal constraint, but instead an unnatural, learned, language-specific constraint.

Finally, Lyman’s Law has been interpreted as a manifestation of the OCP (Obligatory Contour Principle; see KAWAHARA & ZAMMA: §2.3.2), and Nishimura (2003) points out that Lyman’s Law construed this way promotes the devoicing in loanwords of voiced geminate obstruents. In a series of judgment experiments conducted to test the productivity of this devoicing pattern, Kawahara (2011c) found that a voiced obstruent elsewhere in the same word made devoicing of a geminate more natural, and Kawahara (2011a, 2012, 2013) found it made devoicing of singleton voiced obstruents more natural as well. Thus, Lyman’s Law, construed as a constraint against multiple voiced obstruents in a single element, seems to be active not only in blocking rendaku but also in triggering devoicing. Interestingly, in another study of the devoicing of voiced geminate obstruents in loanwords, Kawahara and Sano (2013: 302–303) found a locality effect, in contrast to the absence of such an effect in the case of rendaku and a voiced obstruent in E2 in compounds.

3.5 Some remaining issues

Although there have been a number of experimental studies on rendaku, there are some remaining issues that can and should be addressed in future research. The first issue concerns experimental instructions. Rendaku is far more likely to apply to native Japanese elements than to elements from other vocabulary strata (Otsu 1980:208–210; Ito & Mester 2003a: 148, 2008:85–86), but nonce words are usually treated by native speakers as if they are loanwords. One question that arises is whether it makes sense at all to run experiments on rendaku using nonce words. To address this concern, Vance (1980b) instructed participants to treat nonce word stimuli as obsolete native words. Kawahara (2012) ran an experiment with two different sets of instructions. Some participants were told that the stimuli were old native words, whereas other participants were told that the stimuli were nonce words, but there were no substantial differences in the results between the two conditions. It is important to continue keeping this issue in mind, since it is related to the larger question of whether nonce-word studies are a reasonable way to probe aspects of rendaku, and if so, how.

To elaborate on the “how” question a bit more, recall for example, that Kozman (1998) and Nakamura and Vance (2002) obtained contrary results as to the influence of the semantic role of E1 on the rendaku of E2. The former was a meaning-probe task and the latter was a production task. It therefore seems important to keep exploring what kind of experimental methodology is best suited for tapping Japanese speakers’ linguistic knowledge of rendaku (see Kawahara 2013 for general discussion of task effects in linguistic experimentation).

Another limitation of previous studies is that the methodology is limited to off-line judgment tasks: “wug” tests (as in many of the studies reviewed above), naturalness judgment tasks (Kawahara 2012, etc.), or meaning-probe tasks (Kozman 1998). Experiments that go beyond off-line judgments might provide evidence for the psychological reality of rendaku from a perceptual point of view. For example, it would be interesting to create a voiceless–voiced continuum and investigate whether Japanese speakers show a boundary shift toward voiced responses in an environment where rendaku is expected. It would also be interesting to see whether a shift toward voiceless responses would occur when rendaku would violate Lyman’s Law. This sort of methodology could help to address the psychological reality of rendaku and Lyman’s Law more directly than off-line judgment tasks (see Goldrick 2011 for critical discussion of such tasks).

Finally, there are some aspects of rendaku that have yet to be tested at all. One of these is the tendency for rendaku and unaccentedness to go together in compounds, at least in some sectors of the vocabulary (Yamaguchi 2011). Another

is the strong tendency for coordinate compounds to resist rendaku (Vance 2015b: 425–426). One other is the likelihood of rendaku in compounds that are nouns as opposed to compounds that are verbs or adjectives or that contain deverbal or deadjectival elements. These aspects of rendaku have not been tested, and there is no reason they should not be.

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