# Phonological opacity in Japanese

**Abstract**

Phonological opacity involves a generalization that cannot be stated solely by reference to surface structures. The classic, non-derivational version of Optimality Theory does not predict the existence of phonological opacity, as it is surface-oriented. As one possible response to this problem, a thesis has been advanced to the effect that opacity may not exist as a productive synchronic process. Regardless of whether this strong statement is true of human languages or not, it seems clear that the empirical status of phonological opacity needs to reexamined. In this theoretical context, this paper (i) offers a catalogue of cases of phonological opacity found in Japanese and (ii) provides information about how likely each case is to be treated as a productive pattern in the synchronic phonology of Japanese. This paper generally does not attempt to argue for a definitive answer for each case, but instead provides information that can be used to argue for or against its productivity, so that each researcher can evaluate the likelihood of the synchronic reality of each opaque pattern. Nevertheless, the overall emerging conclusion is that there are no cases of opacity in Japanese, which can be considered to be productive and psychologically real without a doubt.

# 1   Introduction

Phonological opacity involves a generalization that cannot be made solely by reference to surface structures. The classic, non-derivational version of Optimality Theory (OT: Prince & Smolensky 2004) hence does not predict the presence of phonological opacity, as OT is surface-oriented.[1] One type of response proposed by the proponents of OT is to amend the theory, for example, by incorporating derivation back into OT (McCarthy, 2007). Another response takes the prediction of the classic OT seriously, and pursues the idea that those opaque patterns that are not predicted by OT may not actually exist. The latter position is crystalized into the thesis that opacity may not exist as a productive synchronic process, as in (1).

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[1]Since the focus of the paper is not to construct a theory of opacity, these descriptions are very much oversimplified. See also Baković (2011) who argues that not all cases of opacity speak against the classic OT.

(1)    THE THESIS OF NO PRODUCTIVE OPACITY IN PHONOLOGY:
       Phonological opacity does not exist as a synchronically productive phonological pattern. In
       other words, synchronically, phonological opacity is not psychologically real.

Sanders (2003) explicitly declares this thesis and explores its consequence in OT. Green (2004) argues that "[t]he results [of his analysis of Tiberian Hebrew] suggest the possibility that all crosslinguistic instances of apparent opacity can be explained in terms of the phonology-morphology interface and that purely phonological opacity does not exist" (p. 37). Mielke et al. (2003) emphasize the role of historical explanations of opacity, and deemphasize the necessity of explaining opacity synchronically. The thesis in (1) is actually found in some pre-OT literature as well; for example, it also follows from the True Generalization Condition of Natural Generative Phonology, which requires phonological generalizations to be perfectly surface-true (Hooper, 1976). See McCarthy (2007) for discussion and a reply to the thesis in (1) (pp. 1-3, 12-13).

Whether the thesis in (1) is correct or not, it seems important to reexamine the empirical foundation of opaque patterns in general. Pater and McCarthy (2014) propose to examine more carefully whether opacity exists or not in the synchronic patterns of natural languages. This paper agrees that the quality of phonological data should be more carefully examined in general (de Lacy, 2014; Kawahara, 2015). Bruce Hayes, in passing, mentions some statement to this effect in his lecture at "50 Years of Linguistics at MIT", 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".[2] Padgett (2010) also says:

> As Vaux (2008) puts it, "Opaque interactions between phonological processes occur
> in all known natural languages". It is true that facts that linguists can *describe* with
> derivational opacity are widespread...But apparent cases of opacity can often, perhaps
> always, be explained *without* positing opacity. Doing so in some cases might come
> at a cost that is unacceptable to some. But as arguments are made on one side of the
> debate or the other based on theory-internal criteria or elegance, the central question
> that ought to be asked—Is derivational opacity psychologically real?—continues to be
> little asked, because we are unfortunately in a poor position to answer it (emphasis in
> the original, quoted from page 4 of the web version).

I agree that the central question should be whether derivational opacity is psychologically real or not, and that this question should be addressed while or before any theory of opacity is built.

To contribute to addressing this research question of whether there are any productive cases of synchronic opacity, this paper (i) offers a catalogue of cases of phonological opacity found in

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[2]https://www.youtube.com/watch?v=UvQNKTJ598U (see 9:30-10:00)

Japanese and (ii) provides information about how likely each case is to treated as a productive pattern in the synchronic phonology of Japanese. This paper generally does not attempt to argue for a definitive answer for each case, but instead provides information that can be used to argue for or against its synchronic productivity as much as possible, so that each researcher can evaluate the likelihood of the reality of each pattern. Nevertheless, the overall emerging conclusion is that there are no cases of opacity which can be unambiguously considered to be productive and psychologically real.

This paper will be inclusive, so that it will not miss a potential case of opacity, and/or so that it can explicitly argue that a particular pattern does not have to be treated as opaque.

To facilitate the understanding of each phonological interaction, each phonological process is formulated in the SPE style (Chomsky & Halle, 1968), together with references that discuss each pattern and/or the interaction of the two. This paper does not attempt to reproduce or propose an OT analysis, because, again, the focus is the empirical status of each of the opaque patterns; when OT analyses have been proposed in the past, however, this chapter cites and describe them briefly.

## 2   Coda nasalization and emphatic gemination

The two processes are:

(2)     a.     Coda nasalization: $C_i$[+voice] $\rightarrow$ [+nasal] / _ $C_i$[+voice]
        b.     Emphatic gemination: $C_i \rightarrow C_i C_i$ when emphasized

Coda nasalization is related to the phonotactic restriction that native words, Sino-Japanese words, and mimetic words do not allow voiced geminates (i.e. */bb, dd, gg, zz/). (Voiced geminates are allowed in loanwords: Ito & Mester 1995, 1999.) Coda nasalization is observed when an independently motivated gemination process targets a voiced obstruent; the outcome of gemination is a nasal-voiced obstruent cluster. For example, the suffix /-ri/ causes gemination of the last consonants of the stem, as in (3); when the target consonant is a voiced obstruent, however, the coda portion is nasalized, as in (4) (Ito & Mester, 1986, 1999; Lombardi, 1998; McCawley, 1968).

(3)     Gemination associated with /ri-/

        a.     /pita(-pita)/ $\rightarrow$ /pi**tt**ari/ 'precisely'
        b.     /uka(-uka)/ $\rightarrow$ /u**kk**ari/ 'absent-mindedly'
        c.     /biku(-biku)/ $\rightarrow$ /bi**kk**uri/ 'surprised'

(4)     Coda nasalization

        a.     /zabu(-zabu)/ $\rightarrow$ /za**mb**uri/ 'heavy rain'

b. /nobi(-nobi)/ → /no**mb**iri/ 'leaisurely'

c. /uza/ → /u**nz**ari/ 'fed up with'

Emphatic gemination of consonants occurs when speakers express emphasis via gemination (Kawahara, 2013; Nasu, 1999). When these processes interact, coda nasalization fails to apply to the outcome of emphatic gemination (Kawahara, 2002), as in (5). Compare /za**mb**uri/ vs. /za**bb**uuN/ and /u**nz**ari/ vs. /u**zz**ai/, each of which share the same root.

(5)  Voiced geminates created by emphatic gemination

a. /ya**bb**ai/ 'shit'

b. /hi**dd**oi/ 'awful'

c. /su**gg**oi/ 'extremely'

d. /u**zz**ai/ 'annoying'order

e. /za**bb**uuN/ 'splashing'

As in (6), if emphatic gemination is ordered after coda nasalization, then we achieve the expected outcome.[3] Emphatic gemination counterfeeds coda nasalization, because if the order was reversed, it would have fed the coda nasalization process. In other words, coda nasalization underapplies.

(6)  Coda nasalization and emphatic gemination

| The right order | | The wrong order | |
|---|---|---|---|
| UR | /hidoi/ | UR | /hidoi/ |
| coda nasalization | —does not apply— | emphatic gemination | /hiddoi/ |
| emphatic gemination | /hiddoi/ | coda nasalization | /hindoi/ |
| SR | [hiddoi] | SR | *[hindoi] |

Within OT, Kawahara (2002) argued for a system in which optional variants (i.e. emphatic forms) are required to be identical to canonical forms (i.e. non-emphatic forms), by way of a set of violable faithfulness constraints. The idea is similar to that of Benua (1997), but it applies between canonical forms and more colloquial variant forms (see also Steriade 1997 for a similar idea). This "faithfulness to canonical pronunciation" does away with derivational opacity.

One question that can be raised about this opaque interaction is whether emphatic gemination is truly phonological—it could instead be a phonetic implementation rule. One reason to suspect that it may be a matter of phonetic implementation comes from the fact that there can be multiple degrees of lengthening, beyond a usual short-long binary distinction; e.g. [hi**dd**oi], [hi**ddd**oi],

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[3]Forms like [hindoi] may not be entirely ungrammatical. They sound like words in a non-Tokyo dialect (e.g. dialects that retain prenasalization, like the Tohoku dialects).

[hi**dddd**oi], etc. (Kawahara & Braver, 2013, 2014).

However, there are also reasons to suspect that emphatic gemination is phonological as well. First, emphatic gemination by default targets left-most geminable consonants in such a way that it makes the initial syllable heavy (e.g. /pa**tt**a-pata/ rather than /pata**p-p**ata/ 'flipping') (Kawahara, 2013; Nasu, 1999), and this directionality preference implies the influence of some sort of prosodic wellformedness (e.g. requiring heavy syllables to be word-initial: Alber 2002; Beckman 1998; Zoll 1998). Also, emphatic gemination can avoid kinds of geminates that are marked (e.g. fricative geminates, nasal geminates, and even voiced geminates), when the stem-initial consonants are stops, which are more geminable (Kawahara, 2013; Nasu, 1999). For example, /kune-kune/ 'skewed' and /tubu-tubu/ 'granular' are often geminated as /kune**k-k**une/ and /tubu**t-t**ubu/, respectively, which shows that the gemination pattern avoids kinds of geminates that are phonologically marked.

Also, when the target of emphatic gemination is /g/, it is possible to get coda nasalization; e.g. /suŋgoi/ 'super', suggesting that the constraint against /gg/ is not entirely inactive in this context; i.e., in a sense, the "wrong order" in (6) is not entirely impossible for /g/. We would not expect this "re-ordering" if emphatic gemination were purely a matter of phonetic implementation.[4]

# 3   Postnasal voicing and syncope

The two processes at issue are:

(7)    a.   Postnasal voicing: C → [+voice] / [+nasal] _
       b.   Syncope: V → ∅ (sporadic)

Postnasal voicing is found across many languages (Pater, 1999). In Japanese, the native vocabulary (also known as Yamato words) almost always follow this restriction in such a way that all consonants after a nasal are voiced (Ito & Mester, 1995, 1999). Post-nasal voicing is observed in past tense formation, as in (8). The past tense suffix /-ta/ is realized as /da/ after a nasal consonant. Other suffixes that undergo post-nasal voicing are /-tari/ 'continuative', /-tara/ 'conditional', and /-te/ 'gerundive' (McCawley, 1968). Postnasal voicing is also observed in the context of verbal root compounding, as in (9) (Ito & Mester, 1999).

(8)    Postnasal voicing in Japanese: past tense formation

       a.   /tabe+ta/ → /tabeta/ 'ate'
       b.   /sin+ta/ → /si**nd**a/ 'died'

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[4]Unless we follow the view of Anderson (1975), recently revived by McCarthy (2011), in which phonetic implementation rules and phonological rules can be interleaved; i.e. phonetic rules can precede phonological rules.

     c.    /kam+ta/ → /ka**nd**a/ 'bit'

(9)    Postnasal voicing in Japanese: verb root compounding

     a.    /hun+sibaru/ → /hu**n+z**ibaru/ 'to bind tightly'

     b.    /hun+tukeru/ → /hu**n+d**ukeru/ 'to stamp upon'

     c.    /hun+haru/ → /hu**n+b**aru/ 'to resist'

     d.    /hun+kiru/ → /hu**n+g**iru/ 'to give up'

Optional syncope sporadically deletes a vowel of some words in casual speech. This syncope process can create a nasal-stop cluster, and even in Yamato words, post-nasal voicing fails to apply to such clusters, as in (10) (Kawahara, 2002).

(10)    Optional syncope and (the lack of) postnasal voicing

     a.    /anata/ → /a**nt**a/ 'you'

     b.    /nani+ka/ → /na**ŋk**a/ 'something'

     c.    /nani+to/ → /na**nt**o/ 'with what'

     d.    /anosa:/ → /a**ns**a:/ 'hey (very casual)'

     e.    /ani+san/ → /a**ns**an/ 'brother'

     f.    /ani+tjan/ → /a**ɲtj**an/ 'brother'

Derivationally speaking, postnasal voicing should precede syncope, so that by the time syncope creates an environment for postnasal voicing, the latter has missed its chances to apply. In other words, syncope counterfeeds postnasal voicing, or postnasal voicing underapplies.

(11)    Postnasal voicing and syncope

| The right order | | | The wrong order | |
|---|---|---|---|---|
| UR | /anata/ | | UR | /anata/ |
| postnasal voicing | —does not apply— | | syncope | /anta/ |
| syncope | /anta/ | | postnasal voicing | /anda/ |
| SR | [anta] | | SR | *[anda] |

    Within OT, Kawahara (2002) offers a solution to this underapplication by using some sort of output-output faithfulness constraint (Benua, 1997) that requires an optional variant to be identical to the canonical variant (see section 2).

    There are a few concerns about treating this case as a synchronically active process of opacity. First, there are only a handful of examples that instantiate this interaction: those that are shown in (10) are more or less exhaustive.

    The second problem is that it is debatable whether postnasal voicing is an active synchronic

phonological process in Japanese at all. Not only does postnasal voicing fail to apply to non-native words, but there are some native lexical items that do not show postnasal voicing (Fukazawa et al., 2002). Moreover, in a nonce verb inflection experiment reported by Vance (1987), only 24 out of 50 participants showed post-nasal voicing in response to a nonce verb /hom-u/: 14 participants just added /ta/ to the whole verb (/homuta/) and 12 deleted the nasal (/hota/). However, Tateishi (2003) and Fukazawa & Kitahara (2005) argue that postnasal voicing may be active in the adaptation of the English plural suffix -s in that it is more likely to be borrowed as /zu/ after /n/ (e.g. /ʑiin+zu/ 'jeans') than after a vowel (e.g. /sokku+su/ 'socks'). Here it seems that we have conflicting pieces of evidence for the productivity of postnasal voicing in Japanese phonology.

Moreover, syncope is also a sporadic phenomenon, and as far as I know, nobody has formulated the precise environments in which vowels are syncopated.

# 4   Epenthesis and velar deletion

This interaction is observed in verbal conjugation patterns, in particular in stems ending with velar consonants, /k, g/. These stems trigger epenthesis of /i/ when concatenated with suffixes that begin with /t/, like /ta/ (past tense). In addition, velars delete after a stem vowel (in past tense formation).

(12)     a.   Epenthesis: $\emptyset \rightarrow$ /i/ / [velar] _ C
          b.   Velar deletion: [velar] $\rightarrow \emptyset$ / V _ (in verbal conjugation environments)

Derivationally speaking, epenthesis needs to precede velar deletion; velar deletion counterbleeds epenthesis, or epenthesis overapplies. Intuitively speaking, this case is opaque because /k/ triggers the epenthesis of /i/, but it is deleted at the surface; why is it necessary to insert a vowel in the first place if there is no consonant cluster to break up at the surface?[5] The derivational analysis could be that the vowel is inserted before the consonant gets deleted (Davis & Tsujimura, 1991).

(13)     Epenthesis and velar deletion

| The right order |  | | The wrong order | |
|---|---|---|---|---|
| UR | /kak+ta/ | | UR | /kak+ta/ |
| epenthesis | /kakita/ | | velar deletion | /kata/ |
| velar deletion | /kaita/ | | epenthesis | —does not apply— |
| SR | [kaita] | | SR | *[kata] |

One problem with this allegedly opaque interaction is its productivity. Experiments using nonce words have shown that verbal conjugation patterns in Japanese are not fully replicated

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[5]This overapplication of epenthesis is similar to the case of Tiberian Hebrew (McCarthy, 1999).

(Batchelder, 1999; Griner, 2005; Vance, 1987, 1991), and that it is likely that Japanese speakers simply memorize all the inflected forms.

In the first nonce-word study of verbal conjugation patterns, Vance (1987) found that (only) 31 out of 50 participants showed epenthesis when conjugating a nonce verb /hok-u/. Other responses were /hokutta/ (16) or /hota/ (3). A follow-up study (Vance, 1991) also shows that native Japanese speakers do not unambiguously choose the correct past tense form for a /k/-final stem. A later study (Griner, 2005) showed even fewer "correct" epenthesis responses, actually about 10%. A consensus that is emerging from these studies is that verb conjugation patterns are not rule-governed. To quote Vance (1991, p. 156), "[this experimental result] is consistent with the claim that even morphologically regular Japanese verb forms are stored in the lexicon."

One can nevertheless argue that as long as there is a single speaker who shows expected patterns, that should suffice, because every individual grammar should bear on the architecture of Universal Grammar.[6] However, I find this attitude worrisome, because it can easily lead to a cherry-picking strategy in linguistic argumentation. Also, this sort of strategy can lead to the problem of non-replicability.

Also, it is not necessarily the case that this epenthesis+deletion view is the right analysis, although this is what happened historically (*/kakitari/ → /kaita/) (Vance, 1987). For example, one could argue that /k/ is mapped to /i/ as an extreme case of synchronic lenition (Griner, 2005).

Finally, we can formulate velar deletion as applying in intervocalic position. Then, in the wrong order, velar deletion would not apply, unless epenthesis occurs, which may make the rule ordering unnecessary (cf. Kenstowicz & Kisseberth 1979; Koutsoudas et al. 1974 for precedents of this sort of analysis). This case is probably still opaque within OT, because epenthesis is required to "rescue" the coda /k/—most likely from the violation of the CODACOND which prohibits an independent place feature in coda (Ito, 1989)—but that coda /k/ is subsequently deleted; in the words of McCarthy (1999), the cause of epenthesis is not "surface-apparent".

# 5   Voicing assimilation and velar deletion

Stems ending with /g/ involve yet another layer of opacity that stems ending with /k/ do not. In addition to the overapplication of epenthesis, suffix-initial consonants are voiced after [g]. This voicing is arguably a result of voicing assimilation caused by /g/ (Davis & Tsujimura, 1991; McCawley, 1968; Griner, 2005).

(14)    a.    Voicing assimilation: C → [+voice] / [+voice] _

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[6]Cf. the discussion of the stress pattern in Kelkar's Hindi, which is based on data from a single individual, Kelkar (1968). This pattern is subsequently cited and discussed by some important work on Metrical Phonology, with some cautionary remarks (Hayes, 1995; Prince & Smolensky, 2004).

     b.    Epenthesis: $\emptyset \to$ /i/ / [velar] _ C

     c.    Velar deletion: [velar] $\to \emptyset$ / V_ (in verbal conjugation)

Derivationally speaking, voicing assimilation needs to precede epenthesis, to the extent that we want to keep the voicing assimilation local, rather than allowing it to apply across a vowel (Gafos, 1999). In this view, epenthesis counterbleeds voicing assimilation, and as a result voicing assimilation overapplies (Davis & Tsujimura, 1991).

(15)    Voicing assimilation and velar deletion

| The right order | | | The wrong order | |
|---|---|---|---|---|
| UR | /kag+ta/ | | UR | /kag+ta/ |
| voicing assimilation | /kagda/ | | epenthesis | /kagita/ |
| epenthesis | /kagida/ | | voicing assimilation | —does not apply— |
| velar deletion | /kaida/ | | velar deletion | /kaita/ |
| SR | [kaida] | | SR | *[kaita] |

Within OT, an analysis using MAX(voice) is offered by Lombardi (1998). In this analysis, even though the host of the [+voice] feature (e.g. /g/) is deleted, the feature itself migrates onto the suffix-initial consonant.

Regarding the quality of this data for phonological argumentation, the same problem as the /k/-final stem arises: whether these "phonological patterns" are actually internalized by native speakers. A nonce word experiment by Griner (2005) found that only about 30% of the responses involve the "correct" conjugation patterns with both epenthesis and voicing assimilation for /g/-final stems.

# 6   /r/-deletion and /w/-deletion

There is another potential candidate for opacity in Japanese verb formation patterns. The present suffix can realize either as /u/ or /ru/. The former appears when the verb root ends with a consonant, and the latter appears when the root ends with a vowel, as in (16). Kurisu (2012) argues that coronal consonants, including /r/, in affix delete after root-final consonants, as in (17).

(16)    a.    /kak+u/ "write" (consonant-final root)

       b.    /tabe+ru/ "eat" (vowel-final root)

(17)    C[coronal] $\to \emptyset$ /C$_{root}$ _

In addition, Japanese /w/ deletes before vowels except for /a/.

(18)    w-deletion: /w/ → ∅ _ [-low]

Verb roots that end with /w/ take /u/ as its present suffix, but /w/ itself deletes because it is followed by /u/. For example, the verb root /kaw-/ 'to buy' is realized as /ka.u/ rather than /ka.ru/. This interaction is opaque, because it is not clear why both /r/ and /w/ need to be deleted, resulting in a hiatus—deleting two consonants to avoid a consonant cluster is an overkill (Hall et al., 2016). Put differently, /w/-final roots have /u/ as its suffix, just like other consonantal-final roots do, but /w/ is not observed at the surface. In standard OT (Prince & Smolensky, 2004), it is difficult to make sense of why /ka.u/ wins over /ka.ru/, because the desired winner /ka.u/ violates ONSET and incurs an extra violation of MAX for /r/, compared to /ka.ru/ (Hall et al., 2016).

(19)

| /kaw-ru/ | *CC | ONSET | MAX |
|---|---|---|---|
| a. kaw.ru | * | | |
| b. ka.ru | | | * |
| c. ka.u | | * | ** |

This problem can be avoided if /r/ did not exist in the underlying representation: indeed, Hall et al. (2016) argue that this is a case of allormoph selection, and therefore roots like /kaw-/ selects /-u/: at the same of allomorph selection, the consonant /w/ is present. If there is only one consonant when /w/-deletion occurs, then there is no overkill.

# 7   Rendaku and velar nasalization

The next type of opacity concerns rendaku and its blockage.

(20)    a.    Rendaku: C[-son] → [+voice] in E2-initially, where E2 is a second element of a compound.
        b.    Lyman's Law: Rendaku is blocked when E2 has [+voice, -son].
        c.    Velar nasalization: /g/ → [ŋ] / V _ V

Rendaku is a morphophonological process in which the initial obstruents of second members (=E2) of compounds become voiced, as in (21) (Vance & Irwin, 2016). Lyman's Law blocks rendaku when there is already another voiced obstruent in the second member, as in (22) .

(21)    Rendaku

a.       /oo-tako/ → /oo-**d**ako/ 'big octopus'
b.       /oo-sara/ → /oo-**z**ara/ 'big dish'
c.       /hosi-sora/ → /hosi-**z**ora/ 'sky with stars'

d.      /aka-kami → /aka-**g**ami/ 'red paper'

e.      /tome-kane/ → /tome-**g**ane/ 'fixing steal'

(22)    Blockage of rendaku by Lyman's Law

a.      /aka-tamago/ → /aka-**t**amago/ 'red egg'

b.      /aka-kabu/ → /aka-**k**abu/ 'red radish'

c.      /natu-kaze/ → /natu-**k**aze/ 'wind in summer'

d.      /yama-kazi/ → /yama-**k**azi/ 'mountain fire'

In some dialects of Japanese, intervocalic /g/ becomes [ŋ] (Ito & Mester, 1997a; McCawley, 1968; 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 in the sense that the surface [ŋ] acts as if it is a voiced obstruent in that it triggers Lyman's Law, although its surface realization is a sonorant—the other nasals, [m] and [n], do not trigger Lyman's Law, as in (21)d,e. In other words, the blockage of rendaku due to Lyman's Law overapplies and rendaku underapplies, despite the application of velar nasalization.

(23)    Rendaku and velar nasalization

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

A Sympathy analysis of this opaque interaction has been proposed by Ito & Mester (1997b) and Honma (2001), which is also touched upon by McCarthy (1999). A Stratal OT analysis exploiting the distinction between lexical phonology and post-lexical phonology has been pursued by Ito & Mester (2003)—rendaku is considered to occur in the lexical phonology whereas velar nasalization occurs in the post-lexical phonology.

One interesting challenge that this opaque pattern presents to OT is as follows. Since [g] and [ŋ] are in an allophonic relationship (i.e. in complementary distribution), we should consider a case in which [ŋ] appears in the input; e.g. /toŋe/. It seems natural to think that this input is mapped faithfully to /toŋe/, because this is a well-formed output.[7] Then, in order to block rendaku, the underlying /ŋ/ has to be changed to /g/, and then has to turn back to /ŋ/ (Honma, 2001;

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[7]This assumption does not necessarily hold—the Richness of the Base (Prince & Smolensky, 2004) does not require that /toŋe/ be mapped faithfully; it merely requires that it is mapped to some wellformed output, e.g. [tone]. However, why /toŋe/ has to be mapped unfaithfully, when [toŋe] is a wellformed output, would be a challenge to explain.

Ito & Mester, 2003). 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). This opacity pattern is analyzable under a Stratal OT analysis (Ito & Mester, 1997b) or a Sympathy analysis with a markedness selector constraint (Honma, 2001), but not when Sympathy selector constraints are restricted to faithfulness constraints (McCarthy, 1999).

This opacity case is real only to the extent that rendaku can be considered phonological rather than (entirely) lexical (see Kawahara 2015 and Vance 2014 for arguments that rendaku is at least partly phonological). Even rendaku is phonological, there are some ways out. One is to posit that /ŋ/ is an obstruent (i.e. [-sonorant]), even at the surface level, although this postulation is phonetically probably not true (i.e. intervocalic [ŋ] does not involve intraoral air pressure rise that would make spontaneous voicing difficult: Chomsky & Halle 1968).[8] One could also argue that velar nasalization is entirely a matter of phonetic implementation, and hence /g/ is /g/ throughout the phonological derivation. This hypothesis would have a problem dealing with the fact that velar nasalization is affected by some morphological conditions (Ito & Mester, 1997a). Another way out is to formulate Lyman's Law in such a way that it includes surface [ŋ], but this postulation would miss the generalization that [ŋ] is derived from a voiced obstruent.

Yet another way out is to say that Lyman's Law is about orthography prohibiting two diacritics within a morpheme (Kawahara, 2015, 2016): voiced obstruents, as well as /ŋ/, are written with a diacritic mark in Japanese orthography, and hence trigger Lyman's Law. This formulation of Lyman's Law based on orthography may at first sound absurd to many practicing phonologists, but it does have its virtues. First, it accounts for the fact that Lyman's Law systematically ignores voicing in sonorants, because sonorant voicing is not expressed with a diacritic mark in Japanese orthography. It also accounts for why Lyman's-Law driven devoicing of geminates (Kawahara, 2006; Nishimura, 2006) also targets the configuration /p...dd.../ (Kawahara & Sano, 2016), because /p/ is also written with a diacritic mark. Finally, there is a certain sense in which rendaku, which is closely related to Lyman's Law, receives a unitary expression in terms of orthography (Vance, 2007, 2016).

# 8 Compensatory lengthening

Japanese has several cases of compensatory lengthening, and compensatory lengthening is opaque to the extent that (i) it is conceived of as "mora count preservation" (Hayes, 1989) and that (ii) vowels are not associated with moras underlyingly. The two processes involved are:

(24)     a.     Mora assignment: V becomes moraic.

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[8]This speculation has not been tested instrumentally, however, as far as I know.

b. A vowel deletes or becomes a glide; a neighboring vowel soaks up its mora.

Some cases of compensatory lengthening in Japanese are illustrated in (25) and (26):

(25)   /riu/ → [rjuu]

a.   /bar**iu**m/ → [bar**juu**mu] 'barium'
b.   /arumin**iu**m/ → [arumin**juu**mu] 'alminum'
c.   /op**iu**m/ → [op**juu**m] 'opium'

(26)   Labial deletion+glide formation+compensatory lengthening

a.   /r**eba**/ → [r**jaa**] 'if'
b.   /d**ewa**/ → [d**jaa**] 'then'
c.   /kor**e+wa**/ → [kor**jaa**] 'this-TOPIC'
d.   /n**i+wa**/ → [n**jaa**] 'DATIVE-TOPIC'
e.   schematically: /V[-back] C[+labial] a/ → /V[-back] a/ → /Vjaa/

These cases of compensatory lengthening in Japanese have been discussed in the pre-OT literature (Poser, 1988; Vance, 1987). Illustrative derivations are shown in (27).

(27)   Compensatory lengthening

| The right order | | | The wrong order | |
|---|---|---|---|---|
| UR | /riu/ | | UR | /riu/ |
| moraification | /ri($\mu$)u($\mu$)/ | | glide formation | /rju/ |
| glide formation | /rju($\mu\mu$)/ | | moraification | /rju($\mu$)/ |
| SR | [rjuu] | | SR | *[rju] |

If mora assignment happens after glide formation, as in the wrong order, then there is only one vowel to assign a mora to—in this sense, glide formation (partially) counterbleeds mora assignment.[9] Treating compensatory lengthening as a case of opacity appears in several works (Kawahara, 2002; Shaw, 2009; Sprouse, 1997). An easy way out for this Japanese case, however, is to posit that vowels are underlyingly moraic. This postulation probably does not impinge upon the Richness of the Base hypothesis (Prince & Smolensky, 2004), to the extent that vowels are universally moraic—that this restriction is universal, not language-specific. Indeed this postulation may be necessary if moraicity distinguishes glides from vowels.

More problematic is a case in which the deletion of coda consonants would lead to compen-

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[9]A similar problem arises with cases of vowel coalescence, the result of which is usually a long vowel (Hayes, 1990; Kawahara, 2002). If melodic features fuse before mora assignment, then there is only one featural melody, and nothing prohibits the resulting melody from receiving only one mora.

satory lengthening, because it is presumably problematic to postulate underlying syllabification (Blevins, 1995; Hayes, 1989; McCarthy, 2003) and assign a mora to coda consonants (Shaw, 2009; Sprouse, 1997).

# 9 Vowel coalescence and exclamative formation

The two processes at issue are:

(28)  a.  Exclamative formation: stem + /ʔ/ (involving deletion of the present tense suffix)
      b.  Vowel coalescence: /ai/, /oi/ → [ee]

Japanese speakers can form exclamatives by taking a bare adjectival stem without any inflectional ending, with an additional word-final glottal stop, as in (29). As a result of this word formation, the present tense suffix /i/ appears to be deleted.

(29)  Exclamative formation

a.  /suppa-i/ 'sour (present)' vs. /suppaʔ/ 'sour!'
b.  /sugo-i/ 'great (present)' vs. /sugoʔ/ 'amazing!'

In casual speech, stem-final vowels and the present tense suffix /i/ can be fused into one long vowel; e.g., /suppai/ → /supee/ and /sugoi/ → /sugee/ (Kawahara, 2002). Exclamative formation can take the output of this vowel coalescence, and insert a glottal stop with concomitant closed syllable shortening; i.e. /suppeʔ/ and /sugeʔ/. The interaction can be considered opaque, as illustrated in (30).

(30)  Vowel coalescence and exclamative formation

| The right order | | The wrong order | |
|---|---|---|---|
| UR | /suppai/ | UR | /suppai/ |
| vowel coalescence | /suppee/ | exclamative | /suppaʔ/ |
| exclamative | /suppeʔ/ | vowel coalescence | —does not apply— |
| SR | /suppeʔ/ | SR | *[suppaʔ] |

Exclamative formation would delete the suffixal vowel /i/, and therefore if it applies first, as in the wrong order in (30), there is no reason for coalescence to occur. However, vowel coalescence can occur (it does not have to—forms like [suppaʔ] are possible). The application of vowel coalescence is therefore not surface-apparent (McCarthy, 1999) in the sense that vowel coalescence occurs without the trigger, the suffixal [i]. This is overapplication of vowel coalescence and

counterbleeding opacity.

One way to avoid treating this interaction as opaque is to posit that forms that have undergone vowel coalescence (i.e. [suppee] and [sugee]) are already stored in the lexicon, and exclamative formation applies to these forms. Alternatively, we can deploy an Output-Output faithfulness constraint (Benua, 1997) to "transfer" the vowel quality created by vowel coalescence in the present form to the exclamative form.

# 10   High vowel deletion and palatalization

Japanese high vowels between two voiceless consonants are reduced; whether this reduction is "devoicing" or "deletion" has been debated for a long time. If high vowels are indeed deleted, this deletion can be considered to cause opacity. Let us take palatalization of /s/ before /i/ as an example.[10]

(31)    a.    High vowel devoicing: [+high] → ∅ / [-voice] _ [-voice].
        b.    Palatalization: /s/ → [ʃ] / _ /i/.

High vowels delete between two voiceless obstruents, and /s/ becomes palatalized before this deleted /i/. Therefore, palatalization needs to precede vowel deletion:

(32)    Palatalization and high vowel deletion

| The right order | | | The wrong order | |
|---|---|---|---|---|
| UR | /sika/ | | UR | /sika/ |
| palatalization | /ʃika/ | | high vowel deletion | /ska/ |
| high vowel deletion | /ʃka/ | | palatalization | —does not apply— |
| SR | [ʃka] | | SR | *[ska] |

This counterbleeding opacity is real, only to the extent that the high vowels really delete phonologically. However, evidence is mixed. On the one hand, a recent EMA study (Shaw & Kawahara, 2016) suggests that the lingual gesture for devoiced [u] is deleted. Whang (2016) likewise argue that in some environments at least, high vowels are apparently absent, implying deletion.

On the other hand, Nakamura (2003) presents EPG evidence which shows traces of the devoiced vowels' oral gestures. Beckman & Shoji (1984) and Tsuchida (1994) show that these vocalic gestures are perceptible at a level that is above chance (see Fujimoto 2015 for a recent overview). Moreover, the devoiced vowels count as moraic for the calculation of a bimoraic min-

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[10]Other processes that would interact with high vowel deletion include affrication of /t/ before high vowels, palatalization of /t/ after /i/, labialization of /h/ before /u/ and palatalization of /h/ before /i/.

imality requirement: a loanword truncation pattern based on a bimoraic template (Poser, 1990) counts devoiced vowels as containing one mora (e.g. [su̥to] 'strike'). Whether high vowel reduction should be characterized as "devoicing" or "deletion" will probably continue to be discussed, and this case of opacity will depend on whether the vowels are really deleted.

Even if the high vowels are completely absent, there is still a possibility that vocalic features are fused into the preceding consonants. Fusion is one possible non-opaque reanalysis of this sort of "assimilation-and-deletion" interaction (Pater, 1999).

# 11   Summary

Provided below is a summary table:[11]

Table 1: A summary table

| Processes involved | Interaction | Notes |
|---|---|---|
| coda nasalization & gemination | counterfeeding | is gemination phonological? |
| postnasal voicing & syncope | counterfeeding | only six examples |
| epenthesis & velar deletion | counterbleeding | not productive in nonce words? |
| epenthesis & voicing assimilation | counterbleeding | not productive in nonce words? |
| /r/-deletion & /w/-deletion | /r/-deletion overapplies | does /r/ exist in UR? |
| rendaku & velar nasalization | LL underapplies | are rendaku and LL phonological? |
| compensatory lengthening | counterbleeding | may not be opaque |
| vowel coalescence & exclamative | counterbleeding | base forms stored in the lexicon? |
| palatalization & vowel deletion | counterbleeding | it may instead be devoicing or fusion |

Does opacity exist in the phonology of Japanese as a productive synchronic process? Evidence is always mixed, but apparently, no cases can be treated as synchronically productive cases of opacity without a doubt.

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[11]I have limited the discussion to Standard, Tokyo Japanese. For possible cases of opacity in other dialects of Japanese, see Kawahara & Hara (2009) (Hiroshima Japanese) and Sasaki (2008) (Mitsukaido Japanese).

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