Hardening Alternation in the Mitsukaido Dialect of Japanese

Kan Sasaki

Sapporo Gakuin University

Abstract: The Mitsukaido dialect of Japanese has a phenomenon in which a stem-initial fricative turns into a stop (or an affricate) when the stem is the second member of a compound. This hardening alternation results from opaque interactions among four phonological processes: sequential voicing, debuccalization (p→h), continuancy neutralization and consonant devoicing. Consonant devoicing counterfeeds sequential voicing and p→h, and counterbleeds continuancy neutralization. Classic Optimality Theory cannot deal with the phonological opacity behind the hardening alternation. Stratal OT, a weak parallelist OT extension which incorporates level ordering, provides a solution for this phenomenon. Strict parallelist extensions such as Sympathy theory and Candidate Chain theory make the wrong prediction for the hardening alternation.*

Key words: devoicing, hardening, Optimality Theory, phonological opacity, Stratal OT

1. Introduction

The Mitsukaido dialect of Japanese, spoken in the southwestern part of Ibaraki Prefecture, has a mixed phonological system displaying both Tohoku dialect properties, such as intervocalic voicing and consonant devoicing, and southern Kanto dialect properties, such as lack of prenasal consonants. Its mixed nature is also found in morphosyntactic properties like the presence of the dative/allative case particle *-sa* peculiar to Tohoku dialects and the absence of productive anticausative voice, as in southern Kanto dialects. Due to this mixed character, the Mitsukaido dialect is often referred to as *Kanto no Tohoku-hogen* 'Tohoku dialect spoken in Kanto'. The phenomenon I analyze in this paper is the hardening alternation exemplified in (1), a phonological alternation derived from the mixed nature of this dialect.

(1)   Hardening alternations

    s–ts   alternations: sɯki̥-kire: 'taste' – sewa-tsɯ̥ki 'obliging', ʃi̥kage 'device' – bane-tʃi̥kage 'spring-powered device', ʃiki-pɯ̥toN 'mattress' – ʃi̥ta-tʃi̥ki 'a seat of plastic'

    h–p   alternations: ɸɯ̥toN 'bedclothes' – dza-pɯ̥toN 'floor cushion', ɸɯ̥sogɯ 'lack' – ne-pɯ̥sogɯ 'lack of sleep', çi̥kari 'light' – ena-pi̥kari 'lightning', çi̥kaerɯ 'refrain' – kae-pi̥kae 'refrain from buying', ɸɯ̥kɯro 'bag' – e-pɯ̥kɯro 'stomach'

The hardening occurs on the initial obstruent of the second member of a compound. This environment is common to that of sequential voicing or *Rendaku* (voicing of the initial obstruent in the second member of a compound) in Standard Japanese. However, unlike sequential voicing, the hardening is not an independent phonological process[1] but results from the opaque interaction among four phonological processes, namely, sequential voicing, consonant devoicing (devoicing of C_1 accompanying V_1 devoicing in the environment $/CV(N)C_1V_1C_2V_2/$ where C_1 is /z/ or /b/, V_1 is a high vowel, C_2 is a voiceless obstruent), continuancy neutralization of voiced sibilants before high vowels and debuccalization of /p/ (p→h). The hardening occurs when the environments of these processes overlap. In the hardening alternation, consonant devoicing, a phonological process found also in Tohoku dialects, obscures the effects of sequential voicing and p→h and wipes out the condition for continuancy neutralization which had already applied to the coronal obstruent. In terms of traditional generative phonology, consonant devoicing counterfeeds sequential voicing and debuccalization of /p/ and counterbleeds continuancy neutralization.

    The classic form of Optimality Theory (OT: Prince and Smolensky 2004) cannot account for this multiple opaque interaction. The aim of this paper is to provide a weak parallelist (in the sense of Ito and Mester 2001) solution for the opaque interaction yielding the hardening alternation. In order to account for the hardening alternation, I employ Stratal OT (Kiparsky 2000), a weak parallelist OT, as a framework, and posit two distinct constraint rankings within the lexicon, Level 1 (derivational morphology) constraint ranking and Level 2 (inflectional morphology) constraint ranking.

    The structure of this paper is as follows: Section 2 introduces the basic proper-

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[1] The analysis regarding the hardening as an independent process has three flaws, typological unnaturalness, redundancy and obscuring the basis of hardening. The environment where the hardening occurs in (1) is intervocalic position. Weakening rather than hardening is expected to occur in this position crosslinguistically (Kirchner 1998). Hence, regarding the hardening as an independent process leads us to the typologically unnatural and ad hoc analysis. As illustrated in 2.2, the overlap of the independently motivated four phonological processes is the source of hardening. Adding an independent phonological process "hardening" to the grammar of the Mitsukaido dialect decreases phonological opacity but results in grammatical redundancy and also obscures the connection between being a two-way distinction dialect and having hardening.

ties of Mitsukaido dialect, including a sketch of the four phonological processes relevant for the hardening alternations. The difficulty encountered in explaining the hardening alternations within the classic OT architecture is illustrated in Section 3. A Stratal OT solution is proposed in Section 4. In Section 5, I consider the availability of the other OT extensions for phonological opacity to the opaque interaction found in the hardening. Section 6 concludes the discussion.

I limit the scope of this paper to the interaction yielding the hardening alternation. There is another phonological process related to the hardening alternation, intervocalic voicing of stop consonants. This phonological process obscures the condition for sequential voicing and it can be regarded as a process related to the hardening alternation. However, in order to concentrate on the analysis of hardening alternation itself, I do not deal with intervocalic voicing at length and will refer to it only when it is relevant for the discussion.

2. Basic Properties

This section introduces the basic properties of the Mitsukaido phonology. I provide the inventory of consonant phonemes and the allophonic "rules" relevant to the discussion in 2.1 (I use the term 'rule' as a pretheoretical one for the purpose of expository convenience without any theoretical intention). Phonological and morphological conditions of the four phonological processes, the interaction of which results in the hardening alternation, are provided in 2.2.

2.1. Consonant inventory

Despite its similarity to Tohoku dialects regarding phonological processes, the inventory of consonant phonemes of Mitsukaido dialect is basically the same as that of Tokyo dialect. The inventories of consonant phonemes in Mitsukaido, Tokyo, and Tohoku dialects are illustrated in (2).[2] Mitsukaido dialect lacks prenasal stops (˜b, ˜d, ˜g), characteristic of Tohoku dialect, not only as phonemes but also as allophones.[3]

(2)   a.   Consonant inventory of the Mitsukaido dialect (Sasaki 2004a)
           /p, b, t, d, k, g, s, z, h, r, m, n, w, j/
      b.   Consonant inventory of the Tokyo dialect (Shibatani 1990)
           /p, b, t, d, k, g, s, z, h, r, m, n, w, j/

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[2] I omit the archiphonemes /N/ (moraic nasal) and /Q/ (non-nasal moraic consonant) because they are irrelevant for the discussion.

[3] Some researchers assume that voiced–voiceless opposition for Tohoku dialects and the prenasality of voiced consonant is derived through prenasalization (Shibata 1954). In this article, I do not adopt this analysis and I assume that the prenasality as an underlying property. The assumption of underlying prenasality is accommodated with the following diachronic fact: prenasalization has never happened as a diachronic process, while the existence of diachronic de-prenasalization is confirmed by the literature.

c.   Consonant inventory of the Tohoku dialect[4]
      /p, ˜b, t, ˜d, k, ˜g, s, ˜z, h, r, m, n, w, j/

The allophonic rules that determine the phonetic realization of obstruent phonemes are listed in (3). These rules are found also in Tokyo dialect, but the phonetic details are not completely the same.

(3)   Relevant allophonic processes
      Affrication: t→ts/__[+high] (i.e. high vowels [i] and [ɯ], and glide [j])
      Palatalization: s, ts → ʃ, tʃ/__[+high, -back] (i.e. high vowel [i] and glide [j])
      h→ç/__[+high, -back]
      h→ɸ~x/__u (friction caused by labial striction is very weak)
      /g/→[ŋ] except for word-initial position; /g/ is realized as [g] in the word-
          initial position.

Phonemic resemblance extends to vowel inventory: both southern Kanto dialects, including Tokyo dialect, and Mitsukaido dialect have five vowel phonemes /a, i, u, e, o/, although /e/ and /i/ in the Mitsukaido dialect correspond to /i/[5] and /ju/ in southern Kanto dialects, respectively (see Sasaki 2003 for details on the correspondence). Phonemic resemblance stops at the prosodeme. Mitsukaido dialect is characterized as an accentless dialect, while southern Kanto dialects have distinctive accentuation.

2.2. Relevant processes
The hardening alternation is a result of the interaction of four phonological processes, sequential voicing, continuancy neutralization, debuccalization of /p/ (p→h) and consonant devoicing. Conditions and effects of each process are provided from 2.2.1 to 2.2.4. In 2.2.5, the interaction of four phonological processes is illustrated.

2.2.1. Sequential voicing
Sequential voicing, well-studied both in traditional grammar and in generative grammar, turns the initial voiceless obstruent of the second member of a compound into a voiced one. The effect of sequential voicing in Mitsukaido dialect is the same as in Standard Japanese, namely, the initial /p/ ([h]), /t/ and /k/ become [b], [d] and [ŋ], respectively ([ŋ] is an allophone of /g/ in non-word-initial position). See the examples in (4).

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[4] Inoue (1968) advocates a three-way opposition system for the Tohoku dialects, including /p, b, ˜b, t, d, ˜d, k, g, ˜g/. The existence of voiced (non-prenasal) stops is motivated by the existence of exceptional voiceless stops, most of which are derived from the phonological processes other than intervocalic voicing and morphological peculiarity.

[5] The /i/ in southern Kanto dialects corresponds to the /e/ in the Mitsukaido dialect only when it has no onset, e.g., /iki/ 'breath' in southern Kanto dialects corresponds to /eki/ in the Mitsukaido dialect but the word standing for 'wood' is /ki/ in both dialects.

(4)   Sequential voicing

/p/→[b]   tebadagi /te-pataki/ 'handclap', Nmeboʃi /Nme-posi/ 'pickled ume', bagabanaʃi /baka-panasi/ 'talking nonsense', egebana /eke-pana/ 'flower arrangement', herabɯna /pera-puna/ 'Japanese crucian carp'

/t/→[d]   hondana /hoN-tana/[6] 'bookshelf', mizɯdeppo: /mizu-teppo:/[7] 'water pistol'

/s/→[z]   teʒagɯ /te-sjaku/ 'pouring one's own sake', odamaʒakṵʃi /ota-ma-sjakusi/ 'wooden ladle', iwaezage /iwae-sake/ 'sake for celebration', aozora /ao-sora/ 'blue sky', koʒima /ko-sima/ 'small island', ç̣itorizɯmo: /pitori-sumo:/ 'fight windmills'

/k/→[ŋ]   neŋɯse (*nekṵse) /ne-kuse/[8] 'disheveled hair', agaɲire /aka-kire/ 'crack in the skin', teŋama /te-kama/ 'small sickle', sagɯraŋami /sakura-kami/ 'tissue', mizɯŋɯsɯri /mizu-kusuri/ 'liquid medicine', hoʃiŋagi /posi-kaki/ 'dried persimmon'

However, the condition for sequential voicing in this dialect differs from that of Standard Japanese. When the second member of a compound has a voiced obstruent (b, d, g, z) in non-initial syllable, sequential voicing is blocked. This condition, known as Lyman's Law (Lyman 1894), has been analyzed as a case of obligatory contour principle (OCP: Leben 1973, Goldsmith 1976) in non-linear phonology (Ito and Mester 1986). In Standard Japanese, the condition is visible in both the underlying representation and the surface phonetic representation except for the velar obstruent, for which the voiced member /g/ is realized as [ŋ] in non-initial position. Lyman's Law is a relevant condition also in Mitsukaido dialect but it always holds only for the underlying representation. Due to the effect of other processes, i.e. intervocalic voicing (yielding [d~z] and [g] from /t/ and /k/ in intervocalic position), consonant devoicing and the allophonic rule yielding velar nasal, the condition sometimes becomes covert.

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[6] The voicing of /t/, the initial obstruent of the second member of [hondana], cannot be due to intervocalic voicing because /t/ does not stand in the intervocalic position.

[7] The /t/ in /mizu-teppo:/ is in a intervocalic position. In this position, /t/ is a target of intervocalic voicing and also a trigger of consonant devoicing at the same time. In such a situation, consonant devoicing has priority over intervocalic voicing. The example [mitsṵkage] /mizu-kake/, where sequential voicing is not applicable because of the compound consists of object-predicate relationship, illustrates the priority of consonant devoicing. In the case of [mizɯdeppo:] /mizu-teppo:/, voicing rather than devoicing applies to /t/. This voicing could not be due to intervocalic voicing because consonant devoicing might block it. The cause of voicing must be sequential voicing.

[8] The form [neŋɯse] undergoing sequential voicing is exempt from consonant devoicing from the following voiceless obstruent [s]. This is due to the nasality of [ŋ]. The non-nasal voiced consonants derived from the application of sequential voicing are a target of consonant devoicing.

(5)   a.   Lyman's law (overt)

[-...d...] blocks sequential voicing: motʃihada (*motʃibada) /moti-pada/ 'soft fair velvety skin'

[-...b...] blocks sequential voicing: kagesoba (*kagezoba) /kake-soba/ 'buckwheat noodles in soup'

[-...z...] blocks sequential voicing: warɯhɯɯzage (*warɯbɯɯzage) /waru-puzake/ 'prank', kosazi (*kozazi) /ko-sazi/ 'small spoon', aosɯɯzi (*aozɯɯzi) /ao-suzi/ 'blue veins'

b.   Lyman's law (covert)

[-...p...] blocks sequential voicing: sagɯraɸɯɯpɯki /sakura-pubuki/ 'cherry blossom storm', cf. sagɯraŋami /sakura-kami/ 'tissue'

[-...ts...] blocks sequential voicing: bagaʃo:tʃi̥ki /baka-sjo:ziki/ 'honest to a fault', cf. bagabanaʃi /baka-panasi/ 'talking nonsense'

[-...ŋ...] blocks sequential voicing: aŋoçiɲe (*aŋobiŋe) /ago-pige/ 'beard'

[-...d...] does not block sequential voicing: denʃobado /deNsjo-pato/ 'carrier pigeon'

[-...g...] does not block sequential voicing: iwaezage /iwae-sake/ 'sake for celebration'

However, in most cases, the condition of blockage of sequential voicing is recoverable. For velar and labial consonants, the underlying specification of [voice] is easily inferred. As in Standard Japanese, [ŋ] is an allophone of /g/ in non-initial position. The blockage of sequential voicing by [ŋ] is expected from the phoneme-allophone correspondence. Non-geminate [p] in intervocalic position in native and Sino-Japanese stems (sequential voicing applies only for these lexical items) is a result of consonant devoicing of /b/. The underlying specification of [voice] is inferred from the grammatical knowledge with no difficulty. The situation is the same in the case of [g]. The [g] in intervocalic position results from intervocalic voicing applying to /k/. The intervocalic [g]'s underlying nonspecification of [voice] is inferred. On the other hand, the underlying specification of [voice] for coronal obstruents is indicated by the behavior of the segment in sequential voicing, except for /z/ before non-high vowels (in this environment, /z/ does not undergo a process obscuring the specification of [voice], i.e. consonant devoicing).

Sequential voicing is found not only in the compound vocabulary shared with Standard Japanese but in the folk vocabulary such as [iŋe:ʃi] /i-kaesi/ 'cooperation-return'. This indicates that sequential voicing is an active morphophonological processes in the grammar of this dialect.

Sequential voicing interacts with other phonological processes as mentioned above. Sequential voicing feeds continuancy neutralization. Sequential voicing bleeds debuccalization of /p/ (p→h). Consonant devoicing counterfeeds sequential voicing. These interactions are crucial for understanding the hardening alternation and their details are illustrated in the following subsections.

2.2.2. Continuancy neutralization

Japanese dialects are classified into four categories in terms of the phonotactic restriction on continuancy of voiced coronals before [+high] segments (high vowels and glide *j*).

(6) 4-way distinction (Yotsu-gana):   /di, zi,   du, zu/
       3-way distinction (Mitsu-gana):   /   zi,   du, zu/
       2-way distinction (Futatsu-gana): /   zi,   zu/
       1-way distinction (Hitotsu-gana): /   (ˇ)zï   /

Dialects with a four-way distinction are found in Kagoshima Prefecture, Kochi Prefecture and other areas. This type of distinction is the most conservative. Dialects with a three-way distinction are spoken in part of Oita Prefecture. This type of dialect lost the distinction of continuancy on voiced coronal obstruents before /i/ and maintains it before /u/. The one-way distinction is found in Tohoku dialects, known as *Zuzu-ben*, where there is no continuancy distinction before high vowels and the distinction of /i/ and /u/ is neutralized after coronal consonants. The majority of dialects spoken in the remaining areas display a two-way distinction, where there is no continuancy distinction before high vowels and the distinction of /i/ and /u/ is maintained after coronal consonants unlike the one-way distinction dialects. Mitsukaido dialect is classified into this class, as is Standard Japanese.

   The continuancy opposition in two-way distinction dialects including Mitsukaido dialect is schematized in (7).

(7) Continuancy opposition in Futatsu-gana dialects
       {/t/   /s/   /z/}/__[V, +high]   phonological representation

                         [cont]
       {[ts]   [s]   [dz]   [z]}/__[V, +high]   phonetic realization

                   [cont]   [cont]

       Cf. Continuancy opposition in Yotsu-gana dialects
       {/t/   /s/   /d/   /z/}/__[V, +high]   phonological representation

                   [cont]   [cont]
       {[ts]   [s]   [dz]   [z]}/__[V, +high]   phonetic realization

                   [cont]   [cont]

In two-way distinction dialects, before non-high vowels, the phonetic realization of /d/ is [d] wherever it stands. In the same environment, the phonetic realization of /z/ depends on the context. When it stands in the word-initial position or follows a homorganic nasal, /z/ appears as an affricate [dz]. Otherwise, it is realized as a fricative [z]. Before high vowels, the distinction of /d/ and /z/ is neutralized. The stop consonant [d] never occurs before high vowels. The affricate [dz] and

the fricative [z] occur before high vowels. Their occurrence is predictable from the environment. When the preceding element is a word boundary or a homorganic nasal, the affricate [dz] emerges. Otherwise, the fricative [z] occurs. The affricate [dz] and the fricative [z] are considered to be allophones of the same phoneme because the distribution of [dz] and [z] is complementary. I use the symbol /z/ for the voiced coronal obstruent phoneme not only in the environment before non-high vowels but also before high vowels due to their same appearance of allophones. However, the feature [continuant] is assumed to be underspecified for the /z/ before high vowels, while the /z/ before non-high vowels is specified with [continuant]. The reason for the underspecification is two-fold: non-distinctness and interaction with other processes. In this position, the continuancy is not distinctive for voiced coronal obstruents as mentioned above, and the continuancy is predictable from its environment. From the non-distinctiveness and predictability, [continuant] for /z/ before high vowel is redundant and therefore it can be left unspecified. Phonological alternation also supports the underspecification of /z/ in this position. When consonant devoicing applies to the voiced coronal obstruent before high vowels, the resulting segment is [ts], not [s] (for the examples, see 2.2.4). The affricate [ts] is an allophone of /t/ before high vowels and /t/ is an unmarked member for [continuant] in the voiceless coronal obstruents (the marked member is /s/). These facts indicate the underspecification of [continuant] for /z/ before high vowels.[9]

Behind the restriction on continuancy oppositions, I assume the phonotactic constraint *[voice, cont, cor][high], incurring the continuancy neutralization of voiced coronal obstruents before high vowels and glides. The effect of this constraint is visible when voicing processes apply to the voiceless coronal obstruents before high vowels. The examples in (8) and (9) illustrate the interaction between continuancy neutralization and other phonological processes. The data in (8) indicate that sequential voicing feeds continuancy neutralization, i.e. coronal obstruents lose their continuancy opposition when they undergo sequential voicing. Both /t/ and /s/ become [z] in the intervocalic position and, [dz] after a homorganic nasal.

(8)   Sequential voicing feeds continuancy neutralization.
    a. Intervocalic position: /t, s/→[z]
        t(→d)→z (ʒ): /tura/ [tsɯra] 'face', /baka-tura/ [bagazɯra] 'stupid face'
        s→z (ʒ): /sima/ [ʃima] 'island', /ko-sima/ [koʒima] 'small island'

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[9] The result of devoicing of the /voiced coronal+high vowel/ sequence in Yotsu-gana dialects is different from that of Futatsu-gata dialects. According to Ono (1983), in a dialect spoken in Saga prefecture, a Yotsu-gana dialect, devoiced coronal obstruents maintain their continuancy specification. For example, /aduki/ 'adzuki bean' is pronounced as [atsu̥ki], while /zjo:zu-ka/ 'skillful' is pronounced as [ʒo:su̥ka]. This type of difference is not found in the Mitsukaido dialect. The dialectal variation of the realization of consonant devoicing depends on the restriction on the continuancy specification of the voiced coronal obstruents before high vowels.

    b. After homorganic nasal: /t, s/→[dz]

        t(→d)→dz (dʒ): /tume-ru/ [tsɯmeru] 'pack', /kaN-tume/ [kandzɯme]
            'canned food'

        s(→z)→dz (dʒ): /iQ-suN/ [issɯN] '1 sun', /ni-suN/ [nisɯN] '2 sun', /
            san-suN/ [sandzɯN] '3 sun' (sun=3.03cm)

            /siru/ [ʃirɯ] 'soup', /keNtiN-siru/ [kentʃindʒirɯ] 'kenchin soup'

Intervocalic voicing, widespread in Tohoku dialects, also feeds continuancy neutralization. The data in (9) illustrate this transparent interaction. The verbal root /tat-/ meaning 'stand' ends in a voiceless coronal stop. When it stands in a position exempt from intervocalic voicing, the root final consonants realized as [t], as shown in the past form [tatta]. On the other hand, when it stands in a position undergoing intervocalic voicing, it is realized as [d], as illustrated in the negative form [tadane].[10] When it stands in a position where the conditions for both intervocalic voicing and continuancy neutralization meet, i.e. the environment /... Vt+high vowel.../, /t/ is realized as [z], not [dz], undergoing both processes. The present form [tazɯ] illustrates this transparent interaction.

(9)   Intervocalic voicing feeds continuancy neutralization

        /tat-u/ [tazɯ] 'stand-pres'

        cf. /tat-a-ne/ [tadane] 'do not stand', /tat-ta/ [tatta] 'stood'

Consonant devoicing interacts with continuancy neutralization opaquely. This opaque interaction constitutes a part of the hardening alternation. For this interaction, see 2.2.4 and 2.2.5.

2.2.3. Debuccalization of /p/

The voiceless labial stop phoneme /p/ is realized as [h] through the application of debuccalization in the underived environment. This is illustrated in (10a). The /p/ as a part of a geminate is exempt from this process as shown in (10b). This indicates that the target of debuccalization is restricted to the single occurrence of /p/. As illustrated in (10c), the application of sequential voicing to /p/ yields [b]. In terms of rule ordering, this can be captured by the ordering where sequential voicing bleeds (wipes out the condition of) debuccalization of /p/.

(10) a. Debuccalization (p→h) in the underived environment

          /pana/ [hana] 'flower', /pone/ [hone] 'bone'

      b. p→h avoidance through gemination

          /kosi-pone/ [koʃippone] 'hipbone'

      c. Sequential voicing bleeds (wipes out the condition for) p→h

          /eke-hana/ [egebana] 'flower arrangement' (*egehana, *egeHana, *egepana)

          (H stands for voiced h)

There are exceptions to the debuccalization of /p/. The single occurrence of /p/ is

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[10] Miyajima (1961) reports that for some speakers the negative form of 'stand' is [tazane]. This form is considered to be a result of analogy from the present form. The speaker I consulted uses the form without analogy.

not prohibited in loan words (11a) and mimetic words (11b). This can be considered as a consequence of lexical stratification (Ito and Mester 1995). At this point, the situation concerning the debuccalization of /p/ in this dialect is same as in Standard Japanese. The difference between Standard Japanese and the Mitsukaido dialect is seen in the case of derived [p]. The [p]s derived through consonant devoicing are exempt from the application of p→h, as shown in (11c). This indicates that consonant devoicing counterfeeds p→h. As a result of this opaque interaction, some single (non-geminate) [p]s are found in native and Sino-Japanese vocabulary in this dialect.

(11) Non-application of p→h
   a. Loan words: paN 'bread'
   b. Mimetics: pɯɪkɯɯpɯɪkɯɯ, parapara
   c. [p] derived through consonant devoicing: kapi̥kɯɯse: /kabi-kuse:/ 'musty'

2.2.4. Consonant devoicing

Consonant devoicing is a phonological process in which the voiced obstruents /z/ and /b/ are devoiced and realized as [ts] and [p], respectively, through regressive assimilation of voicelessness from the voiceless obstruent in the following syllable, accompanying devoicing of high vowel between target (voiced obstruent) and trigger (voiceless obstruent), in the environment /...Ç̬V$_{[high]}$ÇV.../ ('Ç̬' stands for voiced obstruent and 'Ç̥' stands for voiceless obstruent). The word-initial /z/ and /b/ are exempt from this process.[11] This is illustrated in the alternation in (12).

(12) /zikaN/ [dʒigaN, *tʃi̥kaN] 'time, hour' – /ni-zikaN/ [nitʃi̥kaN] '2 hour'

The output of this process is [...Ç̥V̥$_{[high]}$Ç̥V...]. This segmental sequence is the same as the one yielded by high vowel devoicing found in the majority of Japanese dialects including Standard Japanese (for the detail of high vowel devoicing, the reader may refer to Tsuchida 2001, Yoshida 2002, and the literature cited therein). The high vowel devoicing (/Ç̥V$_{[high]}$Ç̥/→[Ç̥V̥$_{[high]}$Ç̥]) is also operative in the Mitsukaido dialect. The difference between high vowel devoicing and consonant devoicing lies in the underlying representation. Both of the obstruents preceding and following the high vowel in the input must be voiceless for high vowel devoicing, while only the following obstruent is required to be voiceless for consonant devoicing. Concerning the devoicing phenomena, the difference between the Mitsukaido dialect and Standard Japanese can be schematized as in (13).

(13) The Mitsukaido dialect   Standard Japanese

Consonant	High vowel	High vowel
Devoicing	Devoicing	Devoicing
/...Ç̬V$_{[high]}$ÇV.../	/Ç̬V$_{[high]}$Ç̥/	/ÇV$_{[high]}$Ç̥/

$$[Ç̥V̥_{[high]}Ç̥] \qquad\qquad [Ç̥V̥_{[high]}Ç̥]$$

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[11] The non-application of consonant devoicing is considered to be a result of positional faithfulness (Beckman 1995) in word-initial position.

As shown in (14), consonant devoicing occurs in several types of derived environments. Consonant devoicing in compound formation is illustrated in (14a). In the examples in (14b), consonant devoicing occurs in derivational morphology of verbal root and suffix combinations. The examples in (14c) illustrate the consonant devoicing in inflectional morphology. Consonant devoicing is also found in underived environments as shown in (15). The derived nature of voicelessness of [ts] and [p] in (15) can be inferred from the interaction with another phonological process. The [ts] and [p] in (15) blocks sequential voicing like voiced obstruents as mentioned in (5b) above.

(14) Consonant devoicing in derived environment
    a. Compounding
        z→ts (tʃ): atʃi̥tsɯke /azi-tuke/ 'seasoning', hatʃi̥saraʃi /hazi-sarasi/ 'disgrace', mitsɯ̥kage /mizu-kake/ 'sprinkling water'
        b→p: kopɯ̥tʃa /kobu-tja/ 'tea made of powdered kelp', kapi̥kɯ̥se: /kabi-kuse:/ 'musty'
    b. Derivational morphology
    Transitivity alternations
        b→p: kabɯːrɯ /kabur-u/ 'put something on the head (vt)' – kapɯ̥sarɯ /kabusar-u/ 'cover on the head (vi)' – kapɯ̥serɯ /kabuse-ru/ 'cover something on the head (vt)', obɯːɯ /obuw-u/ 'carry a child on one's back (vt)' – opɯ̥sarɯ /obusar-u/ 'be carried on someone's back (vi)', abirɯ /abi-ru/ 'pour water over oneself (vt)'– api̥serɯ /abise-ru/ 'pour water on someone (ditransitive)'
        z→ts: hazɯːrerɯ /hazure-ru/ 'come off (vi)'– hatsɯ̥sɯ /hazus-u/ 'take off (vt)'
    Desiderative formatoin
        z→ts: oːʒirɯ /o:zi-ru/ 'answer' – oːtʃi̥te: /o:zi-te:/ 'want to answer'
        b→p: abirɯ /abi-ru/ 'pour water over oneself'—api̥te: /abi-te:/ 'want to pour water over oneself'
    c. Inflectional morphology
        z→ts: ki̥tsɯ̥kane: /kizuk-a-ne/ 'do not notice'– kizɯeda /kizuk-i-ta/[12] 'noticed', hatʃi̥kane: /pazik-a-ne:/ 'do not snap'– haʒiːda /hazik-i-ta/[13] 'snapped', toʒine: /tozi-ne:/ 'do not close'—totʃi̥ta /tozi-ta/ 'closed'

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[12] The form [kizɯeda] is derived through velar deletion, vowel lowering (lowering targeting /i/ without onset) and intervocalic voicing. Velar deletion removes the root-final /k/. As a result of this process, the stem-final /i/ loses its onset and the /i/ without onset becomes [e], undergoing vowel lowering (for detail of vowel lowering, see Sasaki 2003). The /t/ in the initial position of past tense suffix undergoes intervocalic voicing.

[13] The form [haʒiːda] is derived by the application of velar deletion of the root-final consonant and intervocalic voicing of suffix-initial /t/. It does not undergo vowel lowering to the stem-final /i/ because the coalescence of the root final /i/ and the stem final /i/ wipes out the condition for vowel lowering, i.e., the stem-final /i/ integrated into the preceding /i/ acquires the onset, [ʒ], which is also an onset of the root-final /i/.

b→p: napi̥kane: /nabik-a-ne:/ 'do not wave'– nabi:da /nabik-i-ta/ 'waved', abine: /abi-ne:/ 'do not pour water over oneself'—api̥ta /abi-ta/ 'poured water over oneself'

(15) Consonant devoicing in the non-derived environment[14]

z→ts: ʃo:tʃi̥ki /sjo:ziki/ 'honest', atʃisae /azisae/ 'hydrangea', watsɯ̥ka /wa-zuka/ 'a few'

b→p: kapɯ̥to /kabuto/ 'helmet', ɸɯpɯ̥ki /pubuki/ 'snow storm'

Inside the word, the /...C̥V[high]C̥V.../ sequence is exempted from consonant devoicing in loan and mimetic words as shown in (16a–b). Intervocalic voicing instead of consonant devoicing occurs in mimetic words. The occurrence of consonant devoicing is limited inside the word. The /...C̥V[high]C̥V.../ sequence formed at the word-particle boundary and word boundary is also exempt from consonant devoicing. For the word-particle boundary, intervocalic voicing rather than consonant devoicing applies as illustrated in (16c). As shown in (16d), no voicing alternations occur at the word boundary.

(16) Non-application of devoicing
   a. Loan words: gibɯsɯ /gibusu/ 'plaster cast (from Gips (German))'
   b. Mimetics (cf. intervocalic voicing applies): bɯzɯbɯzɯ (*bɯzɯpɯ̥tsɯ, *bɯtsɯ̥pɯ̥tsɯ), bɯgɯbɯgɯ (*bɯgɯpɯ̥kɯ, *bɯkɯ̥pɯ̥kɯ), biʃibiʃi (*biʃipi̥ʃi), dzɯdazɯda (*dzɯdatsɯ̥ta), dzɯgazɯga (*dzɯgatsɯ̥ka), dzɯgizɯgi (*dzɯgitsɯ̥ki, dzɯki̥tsɯ̥ki)
   c. Word-particle boundary (voicing rather than devoicing): çiʒi-gara (*çitʃi̥-kara) /pizi-kara/ 'from an elbow', mizɯ-ga (*mitsɯ̥-ka) /mizu-ka/ 'water?' (/-ka/ is an interrogative particle)
   d. Word boundary: çibi kireda (*çipi̥ kireda) /pibi kire-ta/ 'got chapped', kɯ: dʒigaN ne: (*kɯ: tʃi̥kaN ne:) /kuw-u zikaN ne:/ 'There is no time to eat'

The targets of consonant devoicing are /z/ and /b/. The voiced velar stop /g/ does not undergo consonant devoicing even when it stands before 'high vowel + voiceless obstruent' sequences; instead, it is realized as [ŋ] in the environment where consonant devoicing applies. The form undergoing sequential voicing [neŋɯse] (/ne-kuse/) 'disheveled hair' is never realized as *[nekɯ̥se]. This form is suggestive in considering the grammatical nature of consonant devoicing. The non-application of devoicing to /g/ is considered to be due to the nasality of [ŋ]. In this dialect, sonorants, including nasals, never undergo devoicing. This restriction does not hold for some dialects spoken in Tohoku areas (see Saito 2000). The phoneme /g/ behaves like a nasal in not allowing consonant devoicing. However, the phoneme /g/ behaves like other voiced obstruents for sequential voicing despite its surface appearance as [ŋ]. The /g/ in the second member of a compound blocks sequential

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[14] The underlying voicing of voiceless obstruents derived from consonant devoicing in the non-derived environment is ascertained by the covert OCP effect, blocking of sequential voicing, illustrated in (5b) in 2.2.1.

voicing, like other voiced obstruents. This mixed behavior of /g/ indicates that the two processes, i.e. consonant devoicing and sequential voicing, apply at different levels. Consonantal devoicing is regarded as a process occurring at the "surface" level because it is sensitive to the phonetic realization of /g/, while sequential voicing is regarded as a process occurring at the "deep" level because it is sensitive to /g/'s underlying feature composition. This asymmetry is important for the solution of phonological opacity I advocate in Section 4.

2.2.5. Overlap of the environment: Interactions

The domains of the four phonological processes differ: the domain for sequential voicing is a compound word, consonant devoicing occurs only inside the word, and continuancy neutralization and p→h occur everywhere, although the manners of application of continuancy neutralization and p→h are not the same, i.e. there is no exception to continuancy neutralization but p→h exceptionally fails to apply to [p] in mimetic and loan words and derived [p]. When the second member of a compound begins with the sequence 'voiceless non-velar obstruent + high vowel + voiceless obstruent', the conditions on the four phonological processes may overlap and these processes interact. The hardening occurs as a result of the interactions of these processes. The data in (17) below illustrates the interactions of sequential voicing and consonant devoicing.

(17)		Sequential voicing	Consonant devoicing
a.	/ago-pige/ [aŋoçiŋe]	n.a.	n.a. (no trigger)
	'beard'		cf. [çiŋe] /pige/ 'beard'
b.	/ko-sima/ [koʒima]	applied	n.a. (no trigger)
	'small island'		cf. [ʃima] /sima/ 'island'
c.	/sakura-pubuki/	n.a.	n.a. (in the initial obstruent)
	[saɡɯɾafu̥pɯ̥ki]		cf. [ɸɯ̥pɯ̥ki] /pubuki/
	'cherry blossom storm'		'snowstorm'
d.	/ne-pusoku/ [nepɯ̥soɡɯ]	applied	applied
	'lack of sleep'		cf. [ɸɯ̥soɡɯ] /pusoku/ 'lack'
e.	/bane-sikake/ [banetʃi̥kage]	applied	applied
	'spring-powered device'		cf. [ʃi̥kage] /sikake/ 'device'
f.	/ko-tuke:/ [kotsɯ̥ke:]	applied	applied
	'pocket money'		cf. [tsɯ̥ka:] /tukaw-u/ 'use'
g.	/baka-tikara/ [baɡatʃi̥kara]	applied	applied
	'prodigious strength'		cf. [tʃikara] /tikara/ 'power'

When the conditions on both sequential voicing and consonant devoicing are not met, the hardening does not occur as shown in (17a). In (17a), not only the underived form but also the second member of the compound undergoes p→h, and the underlying /pige/ realizes as [çiŋe] in both environments. In (17b), the condition on sequential voicing is met but that on consonant devoicing is not, because the second member of the compound does not include a voiceless obstruent in the onset of the second syllable. In this situation, sequential voicing applies but hard-

ening does not. In (17c), sequential voicing is prohibited by Lyman's Law, because the underlying form of the second member of the compound already includes a voiced obstruent /b/. The phonetic form of the compound in (17c) has a potential trigger for consonant devoicing, i.e. a voiceless obstruent, in the onset of the second syllable of the second member in the compound, but there is no target for consonant devoicing, i.e. the voiced obstruent in the onset of the first syllable of the second member. The compound in (17c) undergoes neither sequential voicing nor consonant devoicing in the initial obstruent of the second member, although the second obstruent undergoes consonant devoicing. This indicates that the application of consonant devoicing depends on the application of sequential voicing.

The examples in (17d) and (17e) illustrate the hardening alternations in the forms of h–p and s–ts, respectively. In both cases, the conditions for sequential voicing and consonant devoicing are met in the same locus. The situation is schematized as in Fig 1.
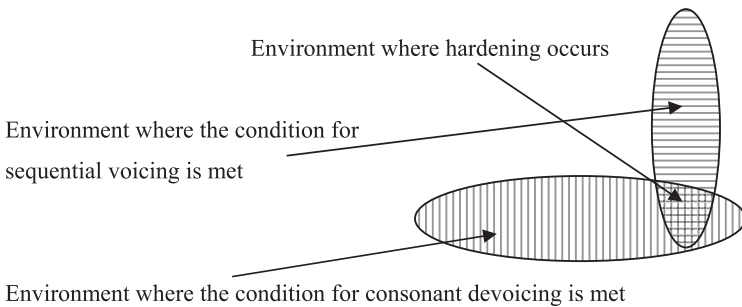
Fig 1.   Overlap

In (17d), the underived form of /pusoku/ is realized as [ɸɯ̥sogɯ], undergoing p→h and the /pusoku/ as a second member of the compound is realized as [...-pɯ̥sogɯ]. The /pusoku/ – [...-pɯ̥sogɯ] mapping in the compound is obtained from the opaque interaction among consonant devoicing, p→h and sequential voicing. Consonant devoicing (b→p) counterfeeds both sequential voicing and debuccalization. The debuccalization process p→h has no effect on the [p] derived through consonant devoicing. The hardening counterpart can be regarded as resulting from a type of Duke-of-York interaction (Pullum 1976) between sequential voicing and consonant devoicing. For voicing specification, the consonant undergoing voiceless → voiced → voiceless derivation in terms of serialist formalism. The hardening "alternation" or "pair" is obtained by the emergence of [h] in the underived form through the application of p→h.

The s–ts alternation in (17e) can be captured under the serialist approach as follows. The underlying representation of the second member of the compound /sikake/ satisfies the condition for sequential voicing and the sequential voicing converts the initial /s/ to z. The z derived through sequential voicing stands before the high vowel [i]. Continuancy neutralization is required in this environment.

Consonant devoicing applies to the voiced coronal obstruent losing its [continuant] specification as a result of continuancy neutralization. The result is [ts], the allophone of /t/ classified as an unmarked member of voiceless coronal obstruents for continuancy.

The overlapping of conditions for sequential voicing and consonant devoicing does not always result in hardening. As illustrated in (17f–g), when the initial consonant of the second member of a compound is /t/, no alternation occurs. This can be regarded as a Duke-of-York interaction between sequential voicing and consonant devoicing, i.e. the underlying /t/ turns into *d* through sequential voicing and this *d*, standing before a high vowel, vacuously satisfies continuancy neutralization because of its lack of [continuant] specification (I assume the feature [continuant] as a privative feature). Subsequent application of consonant devoicing converts *d* to *t*, which is eventually realized as [ts] through the application of allophonic rule (affrication of *t* before high vowels).

The interaction among the four phonological processes can be schematized as in Fig. 2.
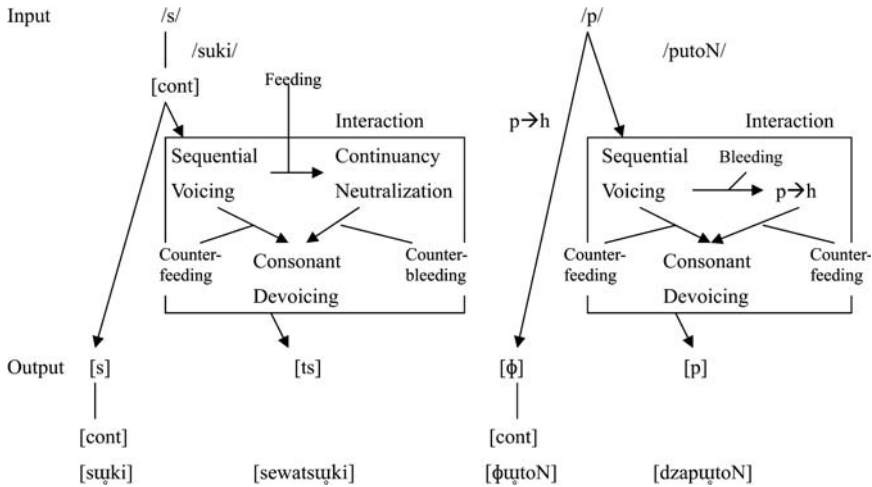
Fig 2.   Interactions of phonological processes behind hardening alternation

A phonological description of the hardening alternation in this dialect must provide an analysis for the multiple opaque interactions behind hardening. In the following sections, I examine whether OT, a parallelist theory, can capture the interactions described above, and argue that a slight modification is necessary incorporating the idea of level-ordered phonology.

3. Failure of Classic OT

Optimality Theory, a formal theory advocated by Prince and Smolensky (2004), attempts to account for grammatical phenomena through the evaluation of candi-

dates generated by Gen from the input with ranked and violable constraints. The output is regarded as the most harmonic candidate. In its classic form, OT can be called a parallelist theory, because the input is directly mapped onto the output with no intermediate levels.

In that theory, phonological processes or rules are a derived notion and the grammars of languages differ not by the existence or absence of processes or rules but in the specific manner of constraint interaction. The application or non-application of phonological processes is assumed to be derived by the relative ranking of the markedness constraints (M) banning a certain phonological structure and the faithfulness constraints (F) prohibiting the modification of the phonological structure banned by M. When M is ranked above F, a phonological process occurs in a manner avoiding the structure banned by M. On the other hand, if M is dominated by F, no alternation happens.

The constraints and partial rankings for the four phonological processes relevant to the hardening alternation are provided in (18)–(21). The partial constraint ranking responsible for sequential voicing is shown in (18). Following Ito and Mester (2003), I assume that a type of morpheme realization constraint (advocated by Kurisu 2001), which requires the feature-sized morpheme composed of [voice] to be linked to the initial obstruent of the second member of a compound, is responsible for sequential voicing. This constraint, dominated by the OCP constraint concerning [voice], triggers sequential voicing only when sequential voicing does not result in the violation of OCP. The relevant faithfulness constraint is Ident(voice). Identity constraints for a certain phonological feature (F) will be henceforth abbreviated as Id(F).

(18) Sequenatial voicing: OCP >> SeqVoi >> Id(voice)
      OCP: Avoid multiple occurrence of [voice] within a stem.
      SeqVoi: Link the feature-sized morpheme [voice] to the initial obstruent
          of second member of compound.
      Id(voice): Do not alter the specification of [voice].

The p→h debuccalization is yielded by the partial constraint ranking (19), where *p dominates Id(cont) and Id (place).

(19) p→h: *p >> Id(cont), Id(place)
      *p: Avoid single occurrence of [p] (Ito and Mester 1995).
      Id(cont): Do not alter the specification of [continuant].

The constraint ranking responsible for continuancy neutralization is (20), where the contextual markedness constraint ConNeut dominates Id(cont). I omit the constraints responsible for the phonetic realization of the segments neutralized with respect to their continuancy for the expository purpose.

(20) Continuancy neutralization: ConNeut >> Id(cont)
      ConNeut: Specification of [continuant] for the voiced coronal obstruent
          before high vowel or glide is prohibited.

I posit an ad hoc contextual markedness constraint Dev as a constraint responsible for consonant devoicing.[15] Under the partial ranking (21), the input including the /...Ç̥V$_{[high]}$C̥V.../ sequence undergoes consonant devoicing, accompanied by devoicing of a following high vowel from Ç̥.

(21) Consonant devoicing: Dev >> Id(voice)
  Dev: The structure /...Ç̥V$_{[high]}$C̥V.../ is prohibited.

Combining the partial constraint rankings (18), (19), (20) and (21), the constraint ranking in (22) is obtained

(22) Combined ranking
  OCP, Dev >> *p, ConNeut >> SeqVoi >> Id(voice), Id(cont)

The constraint ranking presented in (22) evaluates both the underived forms and the forms undergoing each process correctly. See the tableaux in (23). The superscript v at the beginning of the second member of a compound stands for the feature-sized morpheme for sequential voicing. 'ℤ' stands for the voiced coronal obstruent of which continuancy is unspecified.

(23) Evaluation for each process
  a. Sequential voicing: s→z

/ao-ᵛsora/	OCP	Dev	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)
☞ aozora						*	
aosora					*!		

  b. Sequential voicing: p→b

/eke-ᵛpana/	OCP	Dev	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)
☞ egebana						*	
egehana					*!		
egepana			*!		*		

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[15] Sasaki (2004b) argues that constraints for devoicing (both high vowel devoicing and consonant devoicing) can be decomposed into crosslinguistically motivated more basic constraints. The basic constraints are *Liq$_{[s.g.]}$ (ruling out voiceless (=spread glottis) liquids), *NonHiV̥ (prohibiting voiceless non-high vowels), *Ç̥V (penalizing voiceless obstruent – voiced vowel sequence), *VÇ̥ (penalizing voiced vowel – voiceless obstruent sequence), and *ÇV̥ (prohibiting voiced obstruent – voiceless vowel sequence). Dev in (21) is decomposed into *Ç̥V and *VÇ̥. For the input /...ÇV$_{[high]}$C̥V.../, devoicing of voiced obstruent – high vowel sequence can be regarded as a strategy satisfying both *Ç̥V and *VÇ̥. The locally conjoined [*Ç̥V$_1$&*V$_1$Ç̥] is responsible for the high vowel devoicing between voiceless obstruents found in both Standard Japanese and the Mitsukaido dialect. This constraint is considered to be ranked higher than Dev and Id(voice). The permutation of the relative position of Dev and Id(voice) derives the dialectal variation of devoicing phenomema. Under the ranking [*Ç̥V$_1$&*V$_1$Ç̥] >> Dev >> Id(voice), both consonant devoicing and high vowel devoicing are active, as in the Mitsukaido dialect. On the other hand, the ranking [*Ç̥V$_1$&*V$_1$Ç̥] >> Id(voice) >> Dev requires only high vowel devoicing as in Standard Japanese.

c. p→h

	/pana/	OCP	Dev	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)
☞	hana							*
	pana			*!				

d. Continuancy neutralization (with sequential voicing)

	/baka-ˇtura/	OCP	Dev	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)
☞	bagaℤu̥ura						*	*
	bagadzu̥ura				*!		*	
	bagatsu̥ura					*!		

However, with the constraint ranking (22), the forms undergoing hardening, i.e. both sequential voicing and consonant devoicing, are evaluated as suboptimal. The constraint ranking (22) makes the wrong prediction for hardening. The failed evaluations are illustrated in (24). Under the ranking (22), for coronal consonants, the faithful candidate is evaluated as the most harmonic. The tableau (24a) shows that the faithful candidate, the candidate undergoing sequential voicing, and the candidate undergoing both sequential voicing and devoicing all violate the higher ranked markedness constraints. They differ in the violation of the faithfulness constraint. The candidates other than the faithful candidate violate some faithfulness constraint(s). On the other hand, the faithful candidate does not incur a faithfulness constraint violation. The actual form [sewatsu̥ki], after hardening, is evaluated less harmonic than the faithful candidate due to its violation of the faithfulness constraint. The tableau (24b) illustrates the wrong evaluation for the h–p hardening. Among the candidates which satisfy the undominated constraint Dev, the actual candidate [dzapu̥itoN] is less harmonic than the transparent candidate [dzaɸu̥itoN] due to the violation of the markedness constraint *p.

(24) Failed evaluation
    a. /sewa-ˇsuki/ → *sewasu̥ki

	/sewa-ˇsuki/	OCP	Dev	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)
☞	sewasu̥ki					*		
	sewazu̥ki		*!				*	
Actual	sewatsu̥ki					*		*!

    b. /za-ˇputoN/ → *dzaɸu̥itoN

	/za-ˇputoN/	OCP	Dev	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)
Actual	dzapu̥itoN			*!		*		
	dzabu̥itoN		*!				*	
☞	dzaɸu̥itoN					*		*

In order to accommodate the data, certain modifications are required. I will pro-

pose a weak parallelist solution with level ordering within the framework of Stratal OT (Kiparsky 2000).

4. Stratal-OT Solution

The opaque interaction found in both s–ts and h–p hardening takes place between sequential voicing and consonant devoicing. These two processes apply in different domains. Sequential voicing applies in compound formation. Consonant devoicing applies within the word regardless of the morphological environment. As shown in 2.2.4, /g/ behaves differently for two processes: for sequential voicing, it behaves as a voiced obstruent, while, for consonant devoicing, it behaves as a nasal consonant. The domain asymmetry and the phonological behavior of /g/ imply that sequential voicing and consonant devoicing belong to distinct modules, and that the opaque interaction is not due to the processes or constraints themselves, but is rather attributed to the relation between modules. This situation is easily captured by Stratal OT advocated by Kiparsky (2000), a weak parallelist extension of OT integrating the idea of stratum (or level) ordering in Lexical Phonology (Kiparsky 1982, 1985) with OT's parallel evaluation.

Stratal OT recognizes co-phonologies for the grammar of a given language. In this theory, each stratum (or level) can have a distinct constraint ranking and the output of a smaller domain corresponds to the input of a larger domain. For instance, the output of a stem-level process corresponds to the input to a word-level process. The evaluation within each level goes in parallel manner.

In order to capture the opaque interactions behind the hardening alternation, I assume two lexical levels: Level 1, where derivational morphology takes place, and Level 2, where inflectional morphology operates.[16] The constraint ranking for each level is provided in (25).

(25) a. Level 1: OCP, *p, ConNeut >> SeqVoi >> Id(voi), Id(cont) >> Dev
     b. Level 2: ConNeut, Dev >> Id(voi), Id(cont) >> OCP, *p >> SeqVoi

In the Level 1 constraint ranking (25a), markedness constraints incurring p→h, continuancy neutralization and sequential voicing are ranked higher than faithfulness constraints banning these processes, while the constraint Dev responsible for consonant devoicing is lower ranked. Under this constraint ranking, the candidate undergoing p→h, continuancy neutralization and sequential voicing is evaluated as most harmonic when the input includes the structure penalized by the constraints

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[16] The level distinction between derivational and inflectional morphology is supported by another phonological phenomenon, avoidance of consonant sequence. In voice morphology, a domain within derivational morphology, consonant deletion applies in order to avoid consonant sequence, e.g., /kak-rase-ta/ [kagaseda] 'write-causative-past' (cf. /ki-rase-ta/ [kiraseda] 'come-causative-past'), /okur-rare-ta/ [ogɯrareda] 'send-passive-past' (cf. /pome-rare-ta/ [homerareda] 'praise-passive-past'). On the other hand, in past and gerund formation, which belong to inflectional morphology, other phonological processes, such as gemination and moraic nasal formation, apply, e.g., /tor-ta/ [totta] 'take-past', /tob-te/ [tonde] 'fly-gerund'.

responsible for these processes. The most harmonic candidate, i.e. the output of this level, corresponds to the input for Level 2, where the constraint ranking distinct from that in Level 1 determines evaluation. In the Level 2 constraint ranking (25b), markedness constraints responsible for continuancy neutralization and consonant devoicing are ranked higher than faithfulness constraints penalizing these processes, while the constraints, OCP, *p and SeqVoi are ranked lower than the faithfulness constraints. Under this constraint ranking, the candidate undergoing consonant devoicing is evaluated as most harmonic when the input, i.e. the output from the Level 1, includes the structure penalized by Dev.[17]

The difference between the two constraint rankings is characterized by the partial permutation of constraints, demotion of *p and SeqVoi below the faithfulness constraints and promotion of Dev above faithfulness constraints. The positions of ConNeut (responsible for continuancy neutralization) and faithfulness constraints remain intact.

I omit the postlexical constraint ranking responsible for intervocalic voicing in order to restrict the discussion to the interaction yielding the hardening alternation. The domain where intervocalic voicing is active is larger than the word as illustrated in the examples (16c). This indicates that the constraint responsible for intervocalic voicing is higher ranked at the postlexical level.

Evaluation for hardening pairs goes as follows. For the initial /s/ of the noun stem in the underived environment, faithful mapping is regarded as most harmonic at both Level 1 and Level 2. See the tableaux in (26a) and (26b). Thus, the fricative counterpart [s] is obtained in the underived environment. For the stem-initial /s/ before high vowels in the environment satisfying the condition for sequential voicing, Level 1 constraint ranking evaluates the candidate undergoing both sequential voicing and continuancy neutralization as optimal, as in (26c). The output, undergoing both sequential voicing and continuancy neutralization at Level 1, becomes an input for Level 2. The Level 2 constraint ranking evaluates the candidate undergoing consonant devoicing as optimal. The candidate [sewatsɯ̥ki] is more harmonic than [sewasɯ̥ki] because it does not incur the violation of Id(cont) in the Level 2 evaluation. See the tableau in (26d). If the input is not $\mathbb{Z}$ but z at this level, the situation will be reverse. Thus, the 'hard' counterpart [ts] will obtain through the Level 1 and Level 2 evaluations.

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[17] Consonant devoicing is not a structure preserving process in that it requires allophonic information to restrict its target (the nasality of [ŋ] blocks the devoicing of /g/ in intervocalic position) and it yields an allophone, a voiceless high vowel. Structure preservation is considered to be a property of lexical phonology (Kiparsky 1982). However, Borowsky (1993) points out that structure preservation applies at Level 1 but Level 2 phonology does not always exhibit this property in English phonology. In the Mitsukaido dialect, Level 1 phonological processes, such as sequential voicing, continuancy neutralization, and p→h, are structure preserving, but Level 2 phonological process consonant devoicing is not. The situation is parallel to English phonology and supports the weaker version of the structure preservation hypothesis.

(26) Hardening: s–ts alternation

    a. Tableau for Level 1 evaluation of /suki/

/suki/	OCP	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)	Dev
☞ suki							
tsuki						*!	

    b. Tableau for Level 2 evaluation of /suki/

suki	ConNeut	Dev	Id(voi)	Id(cont)	OCP	*p	SeqVoi
☞ su̥ki							
tsu̥ki				*!			

    c. Tableau for Level 1 evaluation of /sewa-ᵛsuki/

/sewa-ᵛsuki/	OCP	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)	Dev
sewasu̥ki				*!			
sewatsu̥ki				*!		*	
sewazuki			*!		*		*
☞ sewaℤuki						*	*

    d. Tableau for Level 2 evaluation of /sewa-ᵛsuki/

sewaℤuki	ConNeut	Dev	Id(voi)	Id(cont)	OCP	*p	SeqVoi
sewasu̥ki			*	*!			
☞ sewatsu̥ki			*				
sewazu̥ki	*!	*		*			
sewaℤu̥ki		*!					

The h–p hardening pair is obtained as follows. For /p/ in the underived environment, the candidate undergoing debuccalization (p→h) is evaluated as optimal and the input /putoN/ corresponds to the output *ɸuton* at Level 1. See the tableau in (27a). The output *ɸuton* from Level 1 becomes the input for the Level 2. As illustrated in the tableau in (27b), faithful mapping is favorable for the input *ɸuton* for the Level 2 constraint ranking because it does not incur any violation of constraints. Thus, the fricative counterpart [ɸ] is obtained. For the stem-initial /p/ before high vowels in the environment satisfying the condition for sequential voicing, Level 1 constraint ranking evaluates the candidate undergoing sequential voicing as optimal as illustrated in tableau (27c). The candidate *zabutoN* is selected as an output from Level 1 and becomes an input for Level 2. The tableau in (27d) shows that the Level 2 constraint ranking evaluates as optimal the candidate undergoing devoicing, but not p→h. The candidate undergoing both devoicing and p→h, namely, [dzaɸʉtoN], is less harmonic than the opaque candidate [dzapʉtoN] because it incurs the violation of Id(cont) dominating *p in the Level 2 constraint ranking. Thus, the 'hard' counterpart [p] is obtained through the Level 1 and Level 2 evaluations.

(27) Hardening: h–p alternation

a. Tableau for Level 1 evaluation of /putoN/

/putoN/	OCP	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)	Dev
putoN		*!					
☞ ɸutoN						*	

b. Tableau for Level 2 evaluation of /putoN/

ɸutoN	ConNeut	Dev	Id(voi)	Id(cont)	OCP	*p	SeqVoi
☞ ɸu̜toN							
pu̜toN			*!			*	

c. Tableau for Level 1 evaluation of /za-ᵛputoN/

/za-ᵛputoN/	OCP	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)	Dev
zaputoN		*!		*			
zaɸutoN				*!		*	
☞ zabutoN					*		*

d. Tableau for Level 2 evaluation of /za-ᵛputoN/

zabutoN	ConNeut	Dev	Id(voi)	Id(cont)	OCP	*p	SeqVoi
☞ dzapu̜toN			*			*	
dzaɸu̜toN			*	*!			
dzabu̜toN		*!					

Stratal-OT can account not only for the hardening alternation but also for another phenomenon the strict parallelist approach cannot deal with easily, namely the covert OCP effect in which sequential voicing is blocked by surface [p] and [ts] in the second member of the compound. As illustrated in (5b), the underlying [voice] specification of [p] and [ts] blocks application of sequential voicing in the examples [saɯɾaɸɯ̜pɯ̜ki] (/sakura-pubuki/ 'cherry blossom storm') and [baɡaʃoːtʃi̜ki] (/baka-sjoːziki/ 'honest to a fault') despite their surface voicelessness.

The situation can be captured as follows. At Level 1, where consonant devoicing is inactive due to the lower ranking of the responsible constraint Dev, the candidate undergoing debuccalization (*sakuraɸubuki*) is evaluated as most harmonic and is selected as output, as illustrated in the tableau in (28a). The candidate undergoing sequential voicing is ruled out because of the violation of the undominated constraint OCP. The faithful candidate is banned for the violation of the undominated constraint *p. At Level 2, for the input *sakuraɸubuki*, the candidate undergoing consonant devoicing is evaluated as the most harmonic (see the tableau in (28b)). The situation is the same in the case of the covert OCP effect with [ts]. As illustrated in the tableau in (28c), at Level 1, OCP is operative due to its undominated status. Thus, the faithful candidate is evaluated as optimal despite the violation of SeqVoi. The most harmonic candidate corresponds to the input for

Level 2. The tableau in (28d) illustrates the Level 2 evaluation, where the candidate undergoing devoicing is evaluated as optimal. In both cases, the covert OCP is derived from the undominated status of OCP at Level 1 and the deletion of the blocker of sequential voicing by the consonant devoicing at Level 2.

(28) Covert OCP effect

    a. Tableau for Level 1 evaluation of /sakura-ᵛpubuki/

/sakura-ᵛpubuki/	OCP	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)	Dev
sakurapubuki		*!		*			
☞ sakuraɸubuki				*		*	*
sakuraɸupuki		*!		*	*		
sakuraɸu̥ɸu̥ki				*	*	*!	
sakurabubuki	*!			*			*

    b. Tableau for Level 2 evaluation of /sakura-ᵛpubuki/

sakuraɸubuki	ConNeut	Dev	Id(voi)	Id(cont)	OCP	*p	SeqVoi
saguɯraɸɯbɯki		*!					
☞ saguɯraɸɯ̥pɯ̥ki			*			*	
saguɯraɸɯ̥ɸɯ̥ki			*	*!			

    c. Tableau for Level 1 evaluation of /baka-ᵛsjo:ziki/

/baka-ᵛsjo:ziki/	OCP	*p	ConNeut	SeqVoi	Id(voi)	Id(cont)	Dev
bakasjo:ziki			*!	*			*
☞ bakasjo:ℤiki				*		*	*
bakasjo:tʃi̥ki				*	*	*!	
bakazjo:ℤiki	*!				*	*	*

    d. Tableau for Level 2 evaluation of /baka-ᵛsjo:ziki/

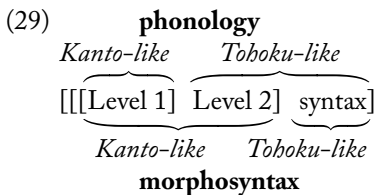| bakasjo:ℤiki	ConNeut	Dev	Id(voi)	Id(cont)	OCP	*p	SeqVoi
bagaʃo:ℤiki		*!					
☞ bagaʃo:tʃi̥ki			*				
bagaʃo:ʃi̥ki			*	*!			

       The division of phonology into Level 1 and Level 2 co-phonologies is useful for understanding the grammatical nature of the Mitsukaido dialect at least in two respects: the sociolinguistic context where this dialect is spoken and the parallelism with other components of grammar.

       The Level 1 and Level 2 division reflects the geographic situation of the dialect. The phonological processes active at Level 1 are continuancy neutralization, sequential voicing and p→h. These are also found in southern Kanto dialects. Sequential voicing in Mitsukaido dialect yields voiced obstruents. This effect is found in the majority of dialects other than Tohoku dialects, where the standard

sequential voicing corresponds to prenasalization. Thus, the Level 1 in this dialect is similar to that of the southern Kanto dialects. Consonant devoicing at Level 2 is also active in Tohoku dialects. However, the result of consonant devoicing is not the same in Mitsukaido and Tohoku. In Mitsukaido dialect, consonant devoicing results in the voiceless obstruents [ts] and [p], while, in Tohoku dialects, it results in the voiceless prenasal stops [ⁿts] and [ⁿp] (see Inoue 1968). This difference is due to the difference of phonemic inventory not to the process itself. Consonant devoicing in both varieties shares the property of deleting the voicing specification of obstruents. Thus, the Level 2 phonology of Mitsukaido dialect can be regarded as Tohoku-like. The postlexical phonology of this dialect exhibits a property of Tohoku dialects in that intervocalic voicing of /k/ and /t/ is active. The Level 1 of Mitsukaido dialect is Kanto-like, whereas its Level 2 phonology and postlexical phonology of this dialect are Tohoku-like. This mixed nature reflects the geographical location of this dialect, spoken on the boundary between Tohoku and southern Kanto.

The mixed characteristics are found in morphology and syntax as well. Mitsukaido dialect lacks a productive anticausative (or spontaneous) intransitivizing suffix, characteristic of Tohoku dialects. In this respect, Mitsukaido dialect's derivational morphology is like that of southern-Kanto dialects. The inflectional morphology of this dialect is also like the southern Kanto dialects in that its tense system has a two-way opposition manifested by present (V-*ru*) and past (V-*ta*) and lacks the V-*tatta* series past tense forms designating direct evidentiality (Kudo 2006) which are found in Tohoku dialects. On the other hand, this dialect shares case particles with the Tohoku dialects, such as -*sa* (dative/allative) and -*godo* (animate accusative). In a nutshell, Mitsukaido dialect resembles southern Kanto dialects in derivational and inflectional morphology, whereas it resembles Tohoku dialects in domains larger than the lexicon.

The distribution of Kanto-like and Tohoku-like properties is schematically represented as in (29).

(29)   **phonology**
  Kanto–like *Tohoku–like*
  [[[Level 1] Level 2] syntax]
   Kanto–like *Tohoku–like*
  morphosyntax

The discrepancy at Level 2 comes from its grammatical nature. Because inflectional morphology (=Level 2 morphology) is "what is relevant to the syntax" (Anderson 1982: 587), it requires syntactic information. Level 2 can be regarded as a crossroads where lexical and syntactic information meets. Kanto-like grammatical properties are predominant at Level 1, the "deep" lexical level, and Tohoku-like properties are predominant in the postlexical module, syntax.

This partial parallelism is easily captured by Stratal OT because of its modular view of grammar. Thus, Stratal OT is useful not only for analyzing the opaque

interaction behind the hardening alternations but also for understanding the grammatical system of the Mitsukaido dialect.

In the next section, I examine other OT extensions that rely on representations other than input and output.

5. Other Approaches

In this section, I examine other OT extensions that share with Stratal OT the property of relying on representations other than input and output, i.e. Sympathy theory and Candidate Chain theory (OT-CC), advocated by McCarthy (1999) and McCarthy (2007), respectively.[18] These two theories are different from Stratal OT in that a single constraint ranking is assumed. Both Sympathy and OT-CC can be regarded as strict parallelist extensions intended to deal with opaque interactions within OT. Among the strict parallelist extensions, I will first examine Sympathy theory, and then OT-CC.

Sympathy theory is built on an extension of faithfulness constraints. In classic OT, faithfulness is a relation between input and candidates generated from the input. Sympathy theory also recognizes a faithfulness relation among candidates. The evaluation under Sympathy theory has two steps. First, a certain IO-faithfulness constraint is designated as a selector, whereby the most harmonic member of the candidates satisfying the selector is selected as the sympathetic candidate. Then, the candidates are evaluated by the constraint ranking with ✾O-faithfulness constraint, which requires resemblance between the sympathetic candidate and the other candidates.

Sympathy theory can accommodate the h–p hardening by assuming the Max(subseg), a faithfulness constraint banning deletion of a floating feature or a

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[18] Several OT extensions other than Sympathy and OT-CC were advocated for the solution of opaque interactions, such as Local Conjunction (Smolensky 1995), Comparative Markedness (McCarthy 2003) and Output-to-Output Correspondence (OO-Correspondence, Benua 1997). I do not discuss these extensions because they are not considered to be available options for the multiple opaque interactions discussed in this paper. Local Conjunction and Comparative Markedness cannot deal with the multiple opaque interaction behind the hardening alternation where both counterfeeding and counterbleeding opacity are found, because, although they can deal with counterfeeding opacity, they cannot deal with counterbleeding opacity. OO-Correspondence is an extension dealing with both counterfeeding and counterbleeding opacity. Under the analysis employing OO-Correspondence, opaque interaction of phonological processes is regarded as a consequence of the higher ranking of the faithfulness constraint among morphologically-related forms (the idea originated from McCarthy and Prince's (1995) faithfulness constraints between base and reduplicated forms). However, for the data discussed in this paper, faithfulness constraints among outputs cannot be regarded as a source of opaque interactions. For hardened forms in the Mitsukaido dialect, the sole morphologically related forms are the underived forms with initial fricatives. Hardening on the initial consonant of the second member in compounds cannot be regarded as a consequence of imitation through identity effect among morphologically-related words.

floating node (Zoll 1996), as a selector (I indicate the selector with the heading ✩) and positing an undominated sympathetic constraint Id⊛O(cont) in the ranking (22). In tableau (30), the candidate undergoing sequential voicing (⊛[dzabɯtoN]) obeys the selector constraint ✩Max(subseg) and is regarded as a sympathetic candidate. This candidate does not survive because of its violation of the undominated constraint Dev. The candidate undergoing p→h ([dzaɸɯ̥toN]) is different from the sympathetic candidate in the specification of [continuant] and is evaluated as sub-optimal because of the violation of Id⊛O(cont). The opaque candidate [dzapɯ̥toN] is evaluated as optimal.

(30)   Evaluation of h–p hardening by Sympathy theory

/za-ᵛputoN/	Dev	Id⊛O(cont)	*p	SeqVoi	✩Max(subseg)	Id(voi)	Id(cont)
☞ dzapɯ̥toN			*	*	*		
dzaɸɯ̥toN		*!		*	*		*
⊛ dzabɯtoN	*!					*	

The s–ts hardening is captured in the same way as illustrated in tableau (31).

(31)   Evaluation of s–ts hardening by Sympathy theory

/sewa-ᵛsuki/	Dev	Id⊛O(cont)	ConNeut	SeqVoi	✩Max(subseg)	Id(voi)	Id(cont)
sewasɯ̥ki		*!		*	*		
☞ sewatsɯ̥ki				*	*		*
sewazɯki	*!		*			*	
⊛ sewaℤɯki	*!					*	*

However, the same constraint ranking makes the wrong prediction for the covert OCP effects. As illustrated in (5b), [p] in [ɸɯpɯ̥ki] and [ts] in [ʃo:tʃi̥ki] block sequential voicing due to their underlying specification of [voice] when they are the second member of a compound. Therefore, the phonetic realization of /sakura-pubuki/ and /baka-sjo:ziki/ are [sagɯraɸɯpɯ̥ki] and [bagaʃo:tʃi̥ki], respectively. However, the candidates undergoing sequential voicing are evaluated as most harmonic in the constraint ranking with Id⊛O(cont) and ✩Max(subseg).

The tableau in (32) illustrates the wrong evaluation for the covert OCP effect of [p]. The candidate in (32f) is the most harmonic among the candidates satisfying ✩Max(subseg) and it is regarded as a sympathetic candidate. The candidate (32g) is evaluated as optimal because it does not incur violation of undominated constraints. The actual form [sagɯraɸɯpɯ̥ki] in (32b) is ruled out because of double violation of Id⊛O(cont).

(32)   Wrong evaluation for covert OCP effect of [p] by Sympathy theory

	/sakura-ᵛpubuki/	Dev	Id⊗O(cont)	*p	SeqVoi	★Max(subseg)	Id(voi)	Id(cont)
	a. sagɯrapɯbɯgi		*!	*	*	*		
Actual	b. sagɯraɸɯpɯki		*!*	*	*	*		
	c. sagɯraɸɯɸɯki		*!		*	*		
	d. sagɯraɸɯbɯgi		*!*		*	*		
	e. sagɯrabɯpɯki	*!	*	*			**	
⊛	f. sagɯrabɯɸɯki	*!					**	*
☞	g. sagɯrapɯɸɯki			*	*	*		

The situation for the covert OCP effect of [ts] is also wrong. The candidate in (33i), undergoing both sequential voicing and continuancy neutralization on the initial consonant of the second member and consonant devoicing on the second consonant, is optimal as well as sympathetic. The actual form [bagaʃo:tʃiki] in (33c), is regarded as less harmonic than (33i).

(33)   Wrong evaluation for the covert OCP effect of [ts] by Sympathy theory

	/baka-ᵛsjo:ziki/	Dev	Id⊗O(cont)	ConNeut	SeqVoi	★Max(subseg)	Id(voi)	Id(cont)
	a. bagaʃo:ʒiki	*!		*	*	*		
	b. bagaʃo:ℤiki	*!			*	*		*
Actual	c. bagaʃo:tʃiki		*!*		*	*	*	*
	d. bagaʃo:ʃiki		*!			*	*	
	e. bagaʒo:ʒiki	*!	*	**			*	
	f. bagaℤjo:ℤiki	*!	*				*	**
	g. bagaʒo:tʃiki		*!*	*			**	*
	h. bagaℤjo:tʃiki		*!				**	**
☞⊛	i. bagaℤjo:ʃiki						**	*

The wrong evaluations in (32) and (33) are due to the undominated status of Dev. Satisfaction of this constraint results in consonant devoicing in the second onset of the second member of the compound. Consonant devoicing removes the blocking element of sequential voicing, i.e. [voice] specification in non-initial onset. In this situation, the candidate that undergoes both sequential voicing and consonant devoicing is preferable because it does not incur the violation of OCP. Thus, one of the candidates undergoing sequential voicing is selected as the sympathetic candidate in (32) and (33), and plays a crucial role in the wrong evaluation. The constraint ranking with sympathy constraint prefers the candidate undergoing both sequential voicing and consonant devoicing. This yields the correct evaluation

in the case of hardening, where the locus of two phonological processes overlaps, but the wrong evaluation in the case of the covert OCP effect, where the locus of two phonological processes does not overlap.

Sympathy theory can account for hardening but not for the covert OCP effect, while Stratal OT can handle both hardening and covert OCP effect (see tableaux in (26), (27) and (28)). The covert OCP effect is derived by the same phonological processes yielding hardening alternations. The difference lies in the locus of application. Thus, Sympathy theory cannot capture the whole range of behavior of the phonological processes comprising hardening alternations. Stratal OT is superior to Sympathy theory in that it accounts not only for hardening itself but also for the related phenomena.

The situation with OT-CC is at first glance better than Sympathy theory. OT-CC can deal with both hardening and covert OCP effect. However, the constraint ranking resolving multiple opaque interactions makes the wrong predictions for the transparent interaction between sequential voicing and continuancy neutralization.

In OT-CC, the object of evaluation is not an individual candidate but a candidate chain. A candidate chain $<f_0, f_1, ..., f_n>$ is formed subject to several conditions (McCarthy 2007: 61). *Faithful first member* requires that the first member of every candidate chain based on the input /in/ is a fully faithful parse of /in/. *Gradualness* requires that a form adds exactly one locally unfaithful mapping to those of its immediate predecessor. *Local optimality* requires that non-initial form in a chain is more harmonic than its predecessor.

Opaque interactions of phonological processes are captured by the Prec constraint, a constraint requiring precedence relation among violations of faithfulness constraints in the candidate chain. Prec(A, B) demands that a faithfulness constraint A be violated before another faithfulness constraint B in a given candidate chain. The violation mark is added for Prec(A, B) when violation of B is not preceded by the violation of A or when A is violated after the violation of B. When both faithfulness constraints A and B dominate Prec(A, B), transparent (feeding or bleeding) interactions are obtained. Under the ranking *A, *B >> B >> Prec(A, B) >> A, where the constraints *A and *B stand for the markedness constraints incurring phonological processes resulting in the violation of faithfulness constraints A and B, respectively, an opaque interaction obtains where a phonological process caused by *B counterbleeds a phonological process caused by *A. The opaque interaction, where a phonological process caused by *B counterfeeds a phonological process caused by *A, is obtained under the ranking, *B >> B >> Prec(A, B) >> *A >> A.

The situation where consonant devoicing counterfeeds sequential voicing and p→h, and counterbleeds continuancy neutralization is captured by the constraint ranking (34), which reflects the general schemata for opaque interactions given above. The undominated constraint $[{}^*\overset{\circ}{C}V_1 \& {}^*V_1 \overset{\circ}{C}]$ is a constraint responsible for high vowel devoicing between voiceless obstruents.

(34) OCP, [*C̥V₁&*V₁C̥] >> Dev, ConNeut >> Max(subseg) >>
  Prec(Id(voi), Max(subseg)) >> SeqVoi >> Id(voi) >> Prec(Id(cont), Id(voi))
  >> *p >> Id(cont)

Under the constraint ranking in (34), for the input /sewa-ᵛsuki/, the candidate chain <sewa-ᵛsuki, sewazuki, sewaℤuki, sewatsu̥ki> is evaluated as most harmonic, as shown in (35). For the expository purposes, I show only final members of the chains in the tableau.

(35)

/sewa-ᵛsuki/	[*C̥V₁&*V₁C̥]	Dev	ConNeut	Max(subseg)	Prec(Id(v), Max(s))	SeqVoi	Id(voice)	Prec(Id(c), Id(v))	Id(cont)
sewa-ᵛsuki	*!					*			
sewazuki		*!	*				*	*	
sewaℤuki		*!					*	**	*
☞ sewatsu̥ki				*			*	**	*

For the input /za-ᵛputoN/, the constraint ranking in (34) correctly evaluates the candidate chain <zaᵛputoN, zabutoN, zapu̥toN> as most harmonic, as shown in (36). The transparent candidate chain of which the terminal member is [zaɸu̥toN] is ruled out because of its violation of local optimality.

(36)

/za-ᵛputoN/	[*C̥V₁&*V₁C̥]	Dev	Max(subseg)	Prec(Id(v), Max(s))	SeqVoi	Id(voice)	Prec(Id(c), Id(v))	*p	Id(cont)
dza-ᵛputon	*!								
dzabutoN		*!				*	*		
☞ dzapu̥toN			*		*	*	*	*	
dzaɸu̥toN			*		*	*	**!		*

The same constraint ranking also deals with the covert OCP effect as shown in (37) and (38).

(37)

/baka-ᵛsjo:ziki/	OCP	Dev	ConNeut	Max(subseg)	Prec(Id(v), Max(s))	SeqVoi	Id(voice)	Prec(Id(c), Id(v))	Id(cont)
bakaᵛsjo:ziki		*!	*			*			
bakaᵛsjo:Ẓiki		*!				*			*
☞ bakaᵛsjo:tʃiki						*	*		*
bakazjo:tʃiki			*!			**			*

(38)

/sakura-ᵛpubuki/	OCP	Dev	Max(subseg)	Prec(Id(v), Max(s))	SeqVoi	Id(voice)	Prec(Id(c), Id(v))	*p	Id(cont)
sakuraᵛpubuki		*!			*			*	
sakuraᵛɸubuki		*!			*				*
☞ sakuraᵛɸupu̥ki					*	*	*	*	
sakuraᵛɸuɸu̥ki					*	*	**!		*

However, the constraint ranking in (34) makes the wrong prediction for the transparent interaction between sequential voicing and continuancy neutralization. The relation where sequential voicing feeds continuancy neutralization is obtained by the partial ranking SeqVoi, ConNeut >> Id(voice), Id(cont) >> Prec(Id(voi), Id(cont)). The constraint ranking in (34) conflicts with this partial ranking for the transparent interaction and makes the wrong prediction illustrated in (39). In order to obtain the correct output, the candidate chain <kentʃinᵛsiru, kentʃinziru, kentʃinẒiru, kentʃindʒiru> must be formed. However, this candidate chain formation violates the local optimality requirement because the second member, which bears a violation mark for the higher ranked ConNeut, is less harmonic than the first member.

(39)

/kentin-ᵛsiru/	ConNeut	Max(subseg)	Prec(Id(v), Max(s))	SeqVoi	Id(voice)	Prec(Id(c), Id(v))	Id(cont)
kentʃinᵛsiru				*			
kentʃinziru	*!				*	*	

The examination above indicates that Sympathy theory and OT-CC are not viable options for dealing with the hardening alternation. It is not clear whether certain modifications could improve the situation or not. However, even if certain modifications would enable Sympathy or OT-CC to deal with the situation concerning the hardening alternation, these theories still could not capture the phenomena within the whole picture of the grammar, e.g. the parallelism between phonology and morphosyntax as a reflection of the sociolinguistic situation, as adequately as Stratal OT.

6. Conclusion

In this article, through the examination of the hardening alternation in the Mitsukaido dialect of Japanese, I show that there is an opaque interaction which cannot be accounted for within OT without introducing serialism. I proposed a weak parallelist solution for the hardening alternation, postulating distinct constraint rankings for Level 1 and Level 2 lexical phonology. Introducing level ordering is useful not only for accounting for the opaque interaction behind the hardening alternation but also for deepening the understanding of the structure of this dialect, in that it enables us to capture the phonology – morphosyntax parallelism and to reflect the sociolinguistic situation of the dialect, i.e. the southern Kanto-like lexicon and Tohoku-like postlexical module.

It is apparent from the discussion in this paper that Stratal OT, a weak parallelist approach, is superior to strict parallelist extensions such as Sympathy theory or OT-CC for the solution of the phonological opacity around the hardening alternation. However, this does not amount to stating that the Stratal OT approach is the best solution for all opacity cases. Opaque interaction within a single stratum is out of scope for Stratal OT. For such opaque interactions, strict parallelist extensions may be more effective. For example, Paradigm Uniformity (Steriade 2000) provides a convincing solution for the counterbleeding opacity between voicing assimilation and velar deletion in Standard Japanese verb morphology (for detail of the analysis, see Sasaki 2005). Seeking out the optimal solution for each problem leads us to a better understanding of the nature of phonological opacity.

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Author's contact information:
Sapporo Gakuin University
11 Bunkyodai, Ebetsu
Hokkaido 069-8555, Japan
e-mail: ksasaki@sgu.ac.jp

【要　旨】

水海道方言における硬化交替

佐々木　冠

札幌学院大学

　水海道方言には，単独用法において摩擦音で現れる語頭の子音が，複合語の第二要素の先頭で閉鎖音（または破擦音）で現れる現象がある。この硬化交替は，四つの音韻プロセス（連濁，p → h，持続性中和，子音の無声化）の不透明な相互作用によって生じる現象である。子音の無声化は連濁と p → h に対して逆投与の関係にあり，持続性中和に対して逆奪取の関係にある。硬化の背後にある音韻的不透明性は古典的な最適性理論では適切な分析ができない。この現象は，レベル間の順序付けを取り入れた弱並列主義の最適性理論（Stratal OT）によって分析が可能になる。共感（Sympathy）理論や候補連鎖（Candidate Chain）理論といった強並列主義の最適性理論の変種では適切な分析を行うことができない。