Probing the unnatural*

Daniel Currie Hall
Meertens Instituut

1. Introduction: The theoretical importance of unnatural classes

As a general rule, we expect phonological patterns to be statable in terms of natural classes of segments. As Hyman (1975: 25) puts it,

the arbitrariness of /s, k, b, r/, as opposed to /s, z, t, d/, is revealed only when an attempt is made to extract the phonetic property shared by all of the segments. When a phonetic property can be extracted, a generalization is revealed. When no phonetic property can be extracted, these segments should not be expected to occur as a class in linguistics.

This expectation is made formally explicit by theories of innate, universal, phonetically contentful phonological features (e.g., Jakobson, Fant, and Halle 1952; Chomsky and Halle 1968; Harris and Lindsey 1995; Clements and Hume 1995; and many others). Mielke (2004, 2008), however, argues that phonological features are neither universal nor innate, but rather language-specific and emergent. Crucial evidence against universal feature theories comes from what Mielke terms ‘unnatural classes’: sets of segments that pattern together as triggers, targets, or blockers of some phonological process, but which cannot be straightforwardly characterized by any conjunction of standard feature values — either because they do not share phonetic properties, or because any properties that they do share are also shared by one or more other segments that do not participate in the same process. Mielke adduces many examples of such unnatural classes, generally presenting them in fairly cursory sketches. This brevity is necessitated by the broad scope of the project. However, as Mielke (2008: 104) himself points out, we should not be too hasty to conclude that existing feature theories are inadequate in any particular case. Because there are many potentially confounding factors, the analysis of any individual apparently unnatural class requires more careful consideration. While Mielke’s work presents an obvious challenge to theories of universal features, the full
significance of the challenge cannot be determined until the specific cases are examined in greater detail. The purpose of this paper is to illustrate four instances in which further scrutiny reveals that a supposedly unnatural class is not so unnatural after all. In two of these cases (Japanese, in §2, and Pero, in §3), the segments in question can be characterized as a natural class; in the other two (Bukusu, in §4, and Kiowa, in §5), the process in which the unnatural class participates can be analyzed as two separate processes without the loss of any important generalizations.

2. Japanese rendaku

Both Mielke (2004, 2008) and Samuels (2009) mention Japanese *rendaku* as an example of a process affecting an unnatural class of segments. Generally speaking, *rendaku* voices a consonant at the beginning of the second member of a non-*dvantva* compound word (unless the second member of the compound already contains another voiced obstruent). The normal application of *rendaku* is illustrated in (1).

(1) Japanese compounds showing the application of *rendaku*


b. [eda] ‘branch’  [ke] ‘hair’  [edage] ‘split end’


Mielke (2004:156–7) observes that the set of segments that undergo *rendaku*, namely /t k s ñ h/, can be described in the feature system of Chomsky and Halle’s (1968) *Sound Pattern of English* (SPE) as sharing certain feature values (most relevantly, [−voice]),

but there is a segment in the complement (/p/) which also shares all of these feature values. As a result, there is no way to distinguish the phonologically active class from the other segments in the language in terms of a conjunction of SPE features, so it is unnatural in the SPE framework.

The identification of the targets of *rendaku* as an unnatural class depends on the assumption that /p/ must somehow be explicitly excluded from the *rendaku* rule. This assumption, however, overlooks the stratification of the Japanese lexicon. *Rendaku* applies primarily — though not quite exclusively — to the native (Yamato) vocabulary of Japanese (Vance 1987: ch. 10). Within this stratum, [p] occurs only as a geminate; the corresponding singleton consonant
is a voiceless fricative that surfaces as [h], [ç], or [φ], depending on the quality of the immediately following vowel (McCawley 1968: 77–8; Labrune 2006: §3.2, §3.7). The distribution of [p], [h], [ç], and [φ] is illustrated in (2), where the symbol Q stands for the moraic obstruent of Japanese, which is realized as the first half of a geminate consonant.

(2) Distribution of [p, φ, ç, h] in Yamato

| [p] / Q _    | e.g., [kappa] | ‘water sprite’ |
| [φ] / _ uu   | e.g., [quuda] | ‘sign’         |
| [ç] / __ i, j | e.g., [çi]    | ‘fire’         |
| [h] / elsewhere | e.g., [hako] | ‘case’          |

The complementarity of [p] and [h] can also be observed dynamically in cases where geminate [pp] alternates with singleton [h]. The name of the country of Japan, for example, can be pronounced either as [nihon] or [nippon] (depending on various mostly extralinguistic factors), but never as *[nihhon] or *[nipon]. Gemination can also be used to mark emphasis, giving rise to pairs such as [jahari] ‘as expected’ and [jappari] ‘as expected (emphatic)’ (Hirayama 2005: 129). The patterning of [p] and [h][φ]/[ç] in the Yamato vocabulary reflects the fact that these phones are historically descended from Old Japanese *p (Labrune 2006: 86 et seq.); if this stratum is considered in isolation, these sounds constitute a single phoneme /p/. In loanwords, however, the distribution of [p] is less restricted, and if the Japanese lexicon is taken as a whole, then the sounds [p], [φ], [ç], and [h] must be considered to constitute two phonemes, /p/ and /h/.

This distributional pattern means that [p] cannot occur in the environment in which *rendaku canonically applies, namely at the beginning of a Yamato word that is the second member of a compound. When the fricative allophones of Yamato /p/ appear in this context, *rendaku applies as expected, and the resulting segment is [b], as in the examples in (3).

(3) Compounds in which *rendaku applies to [h]/[φ]/[ç]


b. [kawa] ‘river’ [quune] ‘boat’ [kawabune] ‘riverboat’

c. [asari] ‘fishing’ [çi] ‘fire’ [isaribi] ‘fishing lure’

In light of this, it seems that there is no need to exclude [p] from the structural description of the *rendaku rule. Rather, the rule can simply be formulated so as to target all voiceless obstruents in the relevant morphophonological environment and lexical stratum; the fact that it does not apply to [p] will follow from the fact that [p] does not occur in the necessary combination of contexts.
Mielke (2008: 14) gives one example in which a [p] occurs at the beginning of the second member of a compound and fails to undergo rendaku; this is shown in (4).

\[(4) \text{[genmai]} \text{‘whole rice’ [pan] ‘bread’} \text{[genmaipan] ‘whole rice bread’} *
\]

The word /pan/, however, is not a native Japanese word, but rather a borrowing from Portuguese pão. Some such well-established borrowings do undergo rendaku, as illustrated in (5).

\[(5) \text{Old borrowings from Portuguese that are subject to rendaku
}\]
\[
\text{a. [uta] ‘poetry’ [karuta] ‘cards’ [utagaruta] ‘poetry cards’ < Port. carta} \\
\text{b. [ame] ‘rain’ [kappa] ‘raincoat’ [amegappa] ‘raincoat’ < Port. capa}^1
\]

Others, however, do not:

\[(6) \text{[ozaʃiki] ‘tatami room’ [tempura] ‘tempura’ [ozaʃikitempura]}
\[
\text{< Port. tempera ‘private tempura’ *[ozaʃikidempura]}
\]

Takayama (2005: 179) suggests that while words such as [karuta] and [kappa], which conform to the phonotactics of the Yamato stratum, have been nativized, other loanwords of equally long standing may resist nativization if their forms mark them as non-Yamato. Under this view, the failure of rendaku to apply to [pan] may be said to be indirectly due to the initial [p] — not because [p] per se is exempt from rendaku, but rather because the presence of singleton [p] identifies [pan] as non-native, and non-native words are exempt from rendaku.

Various objections to this view have been raised. Vance (1996:24) and Ohno (2000:157) argue that describing certain borrowings as having been “nativized” risks circularity. If there is no independent criterion for identifying nativized borrowings, then there is no explanatory value in saying that borrowings that undergo rendaku have been nativized. Rice (1997, 2005) observes that there are similar difficulties inherent in the notion of lexical stratification more generally. She points out that it is difficult to see how a learner acquiring Japanese would come to posit the existence of the more phonotactically restrictive strata at all, or how the learner would decide which stratum is the right one for a morpheme whose phonotactic properties are compatible with more than one. In the worst case, then, it may be necessary to stipulate that
Japanese words are lexically marked as \([\pm \text{rendaku}]\), rather than as belonging to a particular stratum. Alternatively, Rosen (2003) proposes that the resistance of some Yamato words to \textit{rendaku} can be explained by positing an underlying three-way contrast among voiceless obstruents that are unspecified for \([\pm \text{voice}]\), ones that are linked to a \([−\text{voice}]\) feature, and ones that have a floating \([−\text{voice}]\) feature; this set of representations could presumably be extended to the rest of the lexicon, with the vast majority of initial voiceless segments in non-Yamato words being linked to \([−\text{voice}]\) and thus immune to \textit{rendaku}. Under either of these scenarios, the fact that all words beginning with \([p]\) are lexically specified in such a way as to make them immune to \textit{rendaku} would be a matter of historical accident. On the other hand, formulating the rule of \textit{rendaku} to explicitly exclude \([p]\) from the set of possible targets would not eliminate the need for lexical marking in general, as not all words that fail to undergo \textit{rendaku} begin with \([p]\), nor would it capture other generalizations about the phonotactic shapes of words that are or are not subject to the rule.

While it may be necessary to say that \textit{rendaku} applies to a (synchronically) unnatural class of words, there is no insight to be gained by saying that it also applies to an unnatural class of sounds.

3. Pero stop assimilation

Mielke (2008: 144), citing Frajzyngier (1989: 23, 33), discusses stop assimilation in Pero as another example of a process involving an unnatural class. In this case, the set of segments in question are the triggers of the process, rather than the targets. Morpheme-final stops in Pero undergo total assimilation to an immediately following nasal or voiceless stop, as illustrated in (7).

\[
\begin{align*}
\text{(7) Assimilation to nasals and voiceless stops in Pero} \\
\text{a. } /pët+\text{nà}/ & \quad [\text{pënnà}] \text{‘he went out’} \\
\text{b. } /\text{ʧirép}+\text{mü}/ & \quad [\text{ʧirémmù}] \text{‘our women’} \\
\text{c. } /\text{kàp+kò}/ & \quad [\text{kàkkò}] \text{‘he told’} \\
\text{d. } /\text{ʧúp+kò}/ & \quad [\text{ʧókkò}] \text{‘he has shown’}
\end{align*}
\]

An obvious means of identifying these segments as a natural class would be through the use of a feature value such as \([−\text{continuant}]\). However, this would predict that voiced plosives would also be members of the class, as there are no features that nasals and voiceless plosives share with each other that they do not also share with voiced plosives. Mielke points to the data in (8) to argue that voiced plosives trigger epenthesis rather than assimilation, and that the
assimilation rule therefore refers to an unnatural class. (The /p/ in (8a) also undergoes a process of intervocalic lenition that is fed by the epenthesis.)

(8) Epenthesis before voiced stops in Pero
   a. /ká pó+kəjí/ [káviŋjí] ‘eat (habit.)’
   b. /ʃųg+kəjí/ [ʃųgjíŋjí] ‘talk (habit.)’

If the relevant phonological processes in Pero are as Mielke describes them, then it is not obvious that it is necessary to say that the assimilation rule is triggered by an unnatural class of segments. Suppose that the assimilation rule is formulated in such a way as to apply to stops followed by any [−continuant] segment. If the epenthesis rule applies first, then it will bleed the assimilation rule in forms like those in (8), as illustrated in the derivations in (9).

(9) U.R. /pét+nà/ /ká pó+kəjí/ /ʃųg+kəjí/
   Epenthesis – –
   Assimilation pénnà kákkò –
   S.F. [pénnà] [kákko] [ʃųgjíŋjí]

Although (9) presents the pattern as the result of a bleeding interaction between two ordered rules, essentially the same interaction can be formalized in non-derivational terms. In the constraint-based framework of Optimality Theory, the same result might be accomplished by a high-ranking constraint against geminate voiced obstruents, along the lines of Itô and Mester’s (1995:819) *DD, perhaps functionally motivated by the relative difficulty of sustaining voicing in this context. The tableaux in (10) show how this approach would apply to the forms in (7a) and (8b).

(10) a. /pét+nà/ *DD Agree Dep Ident
    – – – *
    [pénnà]
    [pétinà]  *
    [pétànà]

b. /ʃųg+kəjí/ *DD Agree Dep Ident
    – – – *
    [ʃųgjíŋjí]
    [ʃųgjíŋjí] *
    [ʃųgjíŋjí]

In fact, the situation may be somewhat more complicated than this. Frajzynger (1989) presents the data in (8) not as examples of epenthesis before voiced stops, but rather of epenthesis breaking up obstruent clusters that contain
palatals. Such clusters are subject to epenthesis even when the second conso-
nant is underlyingly voiceless, as in (11). (The underlying /k/ undergoes the
same lenition process seen in (8a), and the quality of the epenthetic vowel is
determined by the context.)

(11) Epenthesis in clusters containing palatal consonants
\[
\begin{align*}
\text{a. } & /káʤ+kò/ \quad [káʤóɣò] \quad \text{‘he moved’} \\
\text{b. } & /máʤ+kò/ \quad [máʤóɣò] \quad \text{‘he asked’}
\end{align*}
\]

None of the data presented by Frajzyngier (1978, 1989) shows what happens
when a morpheme-final non-palatal stop is followed by a non-palatal voiced
plosive. In the absence of such examples, it is not possible to be certain wheth-
er the assimilation rule must apply to an unnatural class of segments. If such
clusters are subject to epenthesis, or to some other process distinct from both
epenthesis and assimilation, then some version of the bleeding analysis out-
lined above could explain the non-application of assimilation in this context
without recourse to unnatural classes. If assimilation applies to these clusters,
then the assimilation rule is conditioned by the natural class of non-continu-
ant segments. Only if such clusters surface unaltered is there reason to believe
that assimilation is triggered by an unnatural class.

4. Bukusu nasal deletion

Another case presented by Mielke as an example of a single process condi-
tioned by an unnatural class of segments is that of nasal deletion in Bukusu.
Citing Austen (1975), Mielke (2008: 66–7) shows that nasals in Bukusu delete
both before fricatives, as in (12), and before other nasals, as in (13).

(12) Nasal deletion before fricatives in Bukusu
\[
\begin{align*}
\text{a. } & /i+n+fula/ \quad [eːfula] \quad \text{‘rain’} \\
\text{b. } & /in+som+ij+a/ \quad [esomia] \quad \text{‘I teach’} \\
\text{c. } & /i+n+xele/ \quad [exele] \quad \text{‘frog’}
\end{align*}
\]

(13) Nasal deletion before nasals
\[
\begin{align*}
\text{a. } & /i+n+meel+a/ \quad [eːmeela] \quad \text{‘I am drunk’} \\
\text{b. } & /i+n+nuun+a/ \quad [eːnuuna] \quad \text{‘I suck’} \\
\text{c. } & /i+n+ŋaŋa/ \quad [eːŋaŋe] \quad \text{‘tomato’} \\
\text{d. } & /i+n+ŋuŋuŋa/ \quad [eːŋwanwa] \quad \text{‘camel’}
\end{align*}
\]

Before plosives, which would be included in any obvious natural class that en-
compases both nasals and fricatives, nasals do not delete, but rather (in most
cases) assimilate in place, as in (14). Mielke concludes from this that nasal deletion in Bukusu is conditioned by the unnatural class of fricatives and nasals.

(14) Nasal place assimilation before stops
a. /in+pim+a/ [empima] ‘I measure’

b. /in+bon+a/ [embona] ‘I see’

c. /i+n+goxo/ [engoxo] ‘hen’

One alternative to this conclusion would be to claim that the deletion of nasals in the contexts in (12) and (13) is the result of two separate processes. If the deletion rule that applies in (12) does not target nasals followed by other nasals, then these might be expected to undergo the place assimilation process in (14); the output of assimilation might then be subject to a separate rule of degemination. Derivations along these lines are shown in (15).

(15) U.R. /i+n+fula/ /in+meel+a/ /in+pim+a/
   Nasal deletion ifula – –
   Place assimilation – imeela impima
   Degemination – imeela –
   Other processes⁴ e:fula e:meela empima
   S.F. [e:fula] [e:meela] [empima]

In Optimality Theory, the same effect can be achieved by means of a high-ranking constraint against geminate nasals, or against geminates in general, as discussed below. Mielke (2005: 184, fn. 5) acknowledges this possibility in response to a comment by an anonymous reviewer, but observes that “any pattern involving a featurally unnatural class can be reanalysed as two or more identical patterns involving only featurally natural classes.” He correctly points out that such an analysis should be motivated by independent evidence for the existence of separate processes. The phonotactics of Bukusu provide at least some independent support for the degemination account. Indeed, Mutonyi (2000: 178) specifically claims that “the deletion of nasals before other nasals results from a general ban in the language on sequences of identical segments,” and proposes a constraint NO GEMINATES, formalized as *CiCi.

A sketch of an OT account of Bukusu is shown in (16). Nasal effacement before fricatives, as in (16a), is driven by the constraint *NF, which penalizes surface nasal–fricative sequences. Independent evidence for such a constraint can be found cross-linguistically; in Kongo, for example, such sequences are repaired by affrication of the fricative (Hyman 2003: 51). SHARE(place) triggers assimilation of nasals to following stops, as in (16b). Deletion of nasals before nasals, as in (16b), follows precisely the antigemination pattern predicted by
Baković (2005): a sequence of ‘nearly identical’ consonants is eliminated, not because there is a constraint specifically penalizing consonants that share a particular subset of their features (in this case, [+nasal]), but because the cluster would otherwise become a geminate (in this case, because of the constraint \textit{Share(place)}), and geminates are prohibited by high-ranking \textit{*CiCi}.

\begin{tabular}{|l|c|c|c|c|}
\hline
\text{\textit{ /i+n+fula/}} & \text{\textit{*CiC}_i} & \text{\textit{*NF}} & \text{\textit{Share(place)}} & \text{\textit{Max}} & \text{\textit{Ident}} \\
\hline
\text{\textit{[efula]}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\text{\textit{[enfula]}} & \text{\textit{!*}} & \text{\textit{*}} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\text{\textit{[emfula]}} & \text{\textit{!*}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\end{tabular}

\begin{tabular}{|l|c|c|c|c|}
\hline
\text{\textit{ /in+pim+a/}} & \text{\textit{*CiC}_i} & \text{\textit{*NF}} & \text{\textit{Share(place)}} & \text{\textit{Max}} & \text{\textit{Ident}} \\
\hline
\text{\textit{[epima]}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\text{\textit{[enpima]}} & \text{\textit{!*}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\text{\textit{[empima]}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\end{tabular}

\begin{tabular}{|l|c|c|c|c|}
\hline
\text{\textit{ /in+meel+a/}} & \text{\textit{*CiC}_i} & \text{\textit{*NF}} & \text{\textit{Share(place)}} & \text{\textit{Max}} & \text{\textit{Ident}} \\
\hline
\text{\textit{[e:meela]}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\text{\textit{[enmeela]}} & \text{\textit{!*}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\text{\textit{[emmeela]}} & \text{\textit{!*}} & \text{\;} & \text{\;} & \text{\;} & \text{\;} \\
\hline
\end{tabular}

Under the degemination analysis, it is possible to avoid the conclusion that nasal deletion is triggered by an unnatural class of segments, but at the price of giving up a unified analysis of nasal deletion — the fact that nasals delete both before fricatives and before other nasals becomes a coincidence. On the other hand, treating nasal deletion as a unified phenomenon not only forces the analysis to resort to unnatural classes but also misses the generalization that Bukusu does not permit geminates. Under the unnatural class analysis, it is a coincidence that the nasal deletion rule in some instances contributes to a larger phonotactic pattern.

5. Kiowa vowel height alternations

Alternations in vowel height in Kiowa provide another example of a case in which what Mielke treats as a single process involving an unnatural class can plausibly be treated as two separate phenomena. Citing Watkins (1984), Mielke (2008: 145) reports that Kiowa has a process of “vowel lowering and raising”
before nasals that affects high and low vowels but not mid vowels. The relevant data are shown in (17) and (18).

(17) Vowel lowering and raising in Kiowa
   a. /min/  [mɪ̃n]  ‘about to’
   b. /qun/  [qʊ̃n]  ‘dance/pf.’
   c. /jan/  [jɛ̃n]  ‘2sg.pat:pl/obj.’

(18) Mid vowels unaffected by lowering or raising
   a. /ton/  [tõn]  ‘be fat’
   b. /dɔ̃m/  [dɔ̃m]  ‘earth, ground’

The fact that the changes in vowel height go in two different directions is one indication that perhaps the process that applies to /a/ might be distinct from the one that applies to /i/ and /u/. On the other hand, the effect of both processes is a decrease in the peripherality of the tongue height, and so if the conditioning environment is the same, then it is reasonable to pursue a unified account. Additional data from Watkins (1984: 10), however, indicate that while the lowering of /i/ and /u/ is indeed conditioned by a following nasal, the raising of /a/ in (17c) is actually triggered by the preceding glide. Of particular relevance is the minimal pair in (19).

(19) Minimal pair illustrating the conditioning environment for raising
   a. /sjan/  [ʃɛ̃nʔ]  ‘be small pl.’
   b. /san/  [sãnʔ]  ‘child’

Since lowering and raising are distinct not only in the segments they affect, but also in the environment in which they apply, there is little reason to try to unify them.

6. Conclusions

The four cases discussed in this paper are only a few of the many examples presented by Mielke (2004, 2008) to demonstrate the existence of unnatural classes and the inadequacy of innate, universal, phonetically contentful features. A complete answer to the challenge posed by such cases would require considerably more space, and in many instances also more data than are currently generally available — many of the languages that Mielke discusses are as yet not very thoroughly described in the linguistic literature. The challenge of unnatural classes thus remains a serious one, and one that needs to be examined in greater breadth and depth. At the same time, the cases considered here
illustrate some of the ways in which the appearance of unnatural classes can arise from combinations of independently motivated patterns involving natural classes. In Japanese, the set of segments subject to *rendaku* is constrained not only by the structural description of the rule itself, but also by the distribution of segments in the stratum of the lexicon to which the rule applies. In Pero, the process of stop assimilation is bledd in some of its natural environments by an equally natural process of epenthesis. In Bukusu, two separate processes delete nasals in environments that are similar but that do not quite add up to a natural class. And in Kiowa, high vowel lowering and low vowel raising occur in environments that occasionally overlap, giving the impression that they might be a single process targeting the unnatural class of non-mid vowels. If phonological theory is to come up with an appropriate response to the challenge of unnatural classes, the true scope of the challenge must be assessed in detail.

Notes

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1. The homophony between [kappa] ‘raincoat’ in (5b) and [kappa] ‘water sprite’ in (2) is both accidental and incomplete; the two words differ in the position of pitch accent.

2. An analysis along these lines would be made more difficult by the fact that Pero does permit geminate voiced obstruents in other contexts; see Frajzyngier (1978: 112) for examples.

3. As an anonymous reviewer points out, the form [empima] in (14a) is unexpected, given that Bukusu, as described by Mutonyi (2000) and Hyman (2001, 2003), has post-nasal voicing of stops. As the question of voicing is not crucial to the place assimilation pattern under consideration here, I simply give the form as Austen (1975: 56) transcribes it.

4. The other processes that apply in (15) are vowel lowering and compensatory lengthening.

References


Author’s address

Daniel Currie Hall
Meertens Instituut
Postbus 94264
1090 GG Amsterdam
The Netherlands
daniel.hall@meertens.knaw.nl
daniel.hall@utoronto.ca