It has been pointed out by Katayama (1998) that [ai] and [au] exhibit an asymmetrical pattern in some phonological phenomena in Japanese. Building on this analysis, this paper argues that the asymmetry in question is observed in a much wider range of phonological phenomena in Japanese and, moreover, that this generalization can be extended to other vowel sequences such as [oi], [eu], [ui] and [iu]. The paper also demonstrates that [ai] and [au] exhibit contrastive patterns in English and other languages as well, where [au] forms a less stable and harmonic syllable nucleus than [ai].

Keywords: phonological asymmetry, diphthong, English, Japanese, Korean

1. Introduction

The primary goal of this article is to argue for a markedness distinction among vowel sequences, specifically between [ai] and [au], which presumably represent the two most frequently occurring diphthongs across languages. Evidence for this claim comes largely from a comparative study of English and Japanese, which shows that [au] is much
more marked than [ai] in many ways including its frequency, phonological stability—both synchronic and diachronic—and phonotactic restriction. The following section discusses evidence from English, while section 3 is devoted to an analysis of Japanese. Section 4 extends this discussion to other languages to explore the possibility that the asymmetry between [ai] and [au] is observed across languages. The final section (section 5) summarizes the main points and some remaining questions for future work.

2. English

There are at least two lines of evidence that are suggestive of the markedness of [au] over [ai] in English. They are both from Hammond’s (1999) statistical work on the frequencies and phonotactics of English vowels in general.

2.1. Frequency

Hammond (1999) examined the frequencies of the fifteen monophthongs and diphthongs of English in a database of 20,000 words. This analysis has shown that [ai] is far more frequent than [au] irrespective of the length of words. The following table, taken from Hammond (1999: 106), gives the number of each vowel in that database for words of different lengths. Interestingly, the discrepancy between [ai] and [au] becomes larger as the word becomes longer. Although it is unclear why [au] is so rare in long words, the overall discrepancy between the two diphthongs is evident.

<table>
<thead>
<tr>
<th>Diphthong</th>
<th>No. of syllables</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>[ai]</td>
<td>254</td>
</tr>
<tr>
<td>[au]</td>
<td>108</td>
</tr>
</tbody>
</table>

2.2. Phonotactic Restrictions

Another interesting discrepancy, which seems to account for the asymmetry in Table 1 at least in part, concerns phonotactic restrictions imposed on the two diphthongs. As noted by Hammond, [ai] can stand before a larger number of consonants than [au]. Table 2 displays the
strength of this coocurrence restriction for the two diphthongs in word-final position: /---/ means the absence of an appropriate word.

Table 2 Coocurrence restrictions between the diphthong and the following consonant

<table>
<thead>
<tr>
<th></th>
<th>/-p/</th>
<th>/-t/</th>
<th>/-k/</th>
<th>/-b/</th>
<th>/-d/</th>
<th>/-g/</th>
<th>/-f/</th>
<th>/-θ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ai/</td>
<td>ripe</td>
<td>right</td>
<td>like</td>
<td>bribe</td>
<td>ride</td>
<td>--</td>
<td>rife</td>
<td>blithe</td>
</tr>
<tr>
<td>/au/</td>
<td>---</td>
<td>bout</td>
<td>---</td>
<td>loud</td>
<td>---</td>
<td>---</td>
<td>mouth</td>
<td></td>
</tr>
<tr>
<td>/-s/</td>
<td>/-ʃ/</td>
<td>/-v/</td>
<td>/-ð/</td>
<td>/-z/</td>
<td>/-ʒ/</td>
<td>/-tʃ/</td>
<td>/-dʒ/</td>
<td></td>
</tr>
<tr>
<td>/ai/</td>
<td>rice</td>
<td>---</td>
<td>live</td>
<td>lithe</td>
<td>realize</td>
<td>---</td>
<td>---</td>
<td>oblige</td>
</tr>
<tr>
<td>/au/</td>
<td>mouse</td>
<td>---</td>
<td>mouthe</td>
<td>rouse</td>
<td>---</td>
<td>couch</td>
<td>gouge</td>
<td></td>
</tr>
<tr>
<td>/-m/</td>
<td>/-n/</td>
<td>/-ŋ/</td>
<td>/l/</td>
<td>/r/</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/ai/</td>
<td>time</td>
<td>rine</td>
<td>---</td>
<td>rile</td>
<td>pyre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>/au/</td>
<td>---</td>
<td>town</td>
<td>---</td>
<td>cowl</td>
<td>hour</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As can be seen from Table 2, [ai] combines with coda consonants more freely than [au]: [ai] combines with 16 out of 21 coda consonants, whereas [au] combines with only 11 consonants. In fact, there are seven consonants that can stand after only one of the two diphthongs: six of them can follow [ai], whereas just one, i.e. [tʃ], can follow [au].

Seen from a historical perspective, this is not an accidental asymmetry. Modern English [ai] and [au] derive primarily from Middle English /i:/ and /u:/, respectively, which were diphthongized as part of the English Great Vowel Shift by about 1500 (Ekwall (1965/75)). However, diphthongization of ME /u:/ admitted a number of exceptions in the following phonological environments, whereas diphthongization of ME /i:/ admitted no such notable exceptions (Ekwall (1965/75: 53)).

(1)

a. before a labial: e.g. droop, room, tomb
b. before [k]: e.g. brook (verb)
c. before r + consonant: e.g. mourn, court, source
d. after [w]: wound, swoon, woo

---

1 It seems that the Great Vowel Shift in German was not subject to this type of exception. In Modern German, [ut] occurs before labial consonants and [k]: e.g. Raum ‘room, space,’ Baum ‘tree,’ Raub [raup] ‘robbery,’ Lauf ‘run,’ tauglich [tauk.liç] ‘useful.’
(1a) probably accounts for the absence of [au] before labial consonants in Table 2, i.e. before [p], [b], [f], [v] and [m]. Similarly, (1b) explains why [au] + [k] is not observed in the same table. The exceptions in (1a, b) can, in turn, be attributed to the phonetic fact that [u:], but not [i:], shares articulatory features with labial and velar consonants. In other words, the blocking of diphthongization of /au/ in (1a) and (1b) can be attributed to an assimilatory force to preserve the sequence of a vowel and a homorganic consonant. The same factor seems responsible for the blocking of /u:/ diphthongization in (1d), since [w] also shares place features with [u]. In any case, it is clear that creation of [au] was prohibited in certain phonological contexts, whereas creation of [ai] was not subject to any such constraint in the history of English.

Incidentally, the discrepancy between [ai] and [au] disappears when they combine with consonant clusters. Namely, both diphthongs do not generally combine with consonant clusters (Table 3). This is attributable to an independent constraint that defines the maximality of the syllable (Kubozono (1995), Hammond (1999)).

Table 3 Cooccurrence restrictions between the diphthong and the following consonant clusters

<table>
<thead>
<tr>
<th></th>
<th>/-sp/</th>
<th>/-st/</th>
<th>/-sk/</th>
<th>/-lp/</th>
<th>/-lt/</th>
<th>/-lk/</th>
</tr>
</thead>
<tbody>
<tr>
<td>/ai/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/au/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-mp/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-nt/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-ŋk/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-ps/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-ts/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-ks/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-pt/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>/-kt/</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

In sum, [ai] can cooccur with a coda consonant more freely than [au] in English. This synchronic asymmetry between the two diphthongs seems to appear in a more remarkable way in Japanese, as we will see in the following section.

3. Japanese

Japanese provides several independent pieces of evidence which suggest that [au] is more marked than [ai]. As far as I know, the first person to note this asymmetry is Motoko Katayama, who pointed out the following three facts (Katayama (1998)). First, loanwords from
English tend to retain the diphthong [ai] in the English vowel sequence of [aiə] while turning [au] into [a] in the sequence [auə]. Second, there is no Sino-Japanese (SJ) morpheme containing [au], whereas a number of SJ morphemes contain [ai]. Third, [au] has shown a historical tendency to turn into the monophthong [o:] in the adjectival morphology of native Japanese words, whereas [ai] remains quite stable.

In this section, I will demonstrate that [ai] is more stable than [au] in a wider range of phenomena of Japanese. Section 3.1 discusses statistical frequencies with which the two vowel sequences occur in each of the three types of Japanese morphemes—SJ, native and foreign. Section 3.2 considers the historical background of this synchronic state of affairs to understand why [ai] enjoys a higher frequency than [au] in the synchronic grammar. The next five sections (3.3 through 3.7) analyze the asymmetry between [ai] and [au] in the loanword phonology and morphophonology of contemporary Japanese.

3.1. Lexical Strata and Frequency

The first line of evidence for the markedness of [au] over [ai] comes from an analysis of the frequencies with which the two vowel sequences occur in Japanese morphemes. In modern Tokyo Japanese, [ai] occurs in a larger number of morphemes than [au]. Of the three types of morphemes in Japanese, SJ morphemes exhibit the most remarkable asymmetry. As Katayama (1998) pointed out, [ai] is very commonly observed but [au] is not attested at all in this type of morpheme. This has been borne out by my own analysis of all SJ morphemes listed in the appendix to a Japanese dictionary (Nagasawa (1959/82)). This analysis gives 407 SJ morphemes containing [ai], but no instance containing [au].

A similar but more moderate asymmetry is observed in native Japanese (or so-called Yamato) morphemes. My analysis of native morphemes listed in the same appendix shows that [ai] occurs in 63 morphemes, whereas [au] is attested only in 29 morphemes.\(^2\) Most of

\(^2\) [ai] is generally more frequent than [au] irrespective of the type of the preceding consonant. The only exception to this general tendency is the case where the word begins with the vowel sequence, i.e. with an onsetless syllable: seven morphemes begin with [ai], e.g. ai 'indigo (plant),' as opposed to nineteen morphemes which begin with [au], e.g. au 'to meet.'
the 29 native morphemes containing [au] are verbal forms such as *au* 'to meet,' *kau* 'to keep (an animal)' and *mau* 'to dance.' These forms may be analyzed as consisting of two morphemes rather than one. Thus, *kau* derives from the concatenation of a verbal stem /kaw/ and an ending /u/ just as *tobu* 'to fly' derives from /tob/ + /u/, with the former but not the latter undergoing an independent process of /w/ deletion before a non-low vowel. Even if we assume that [au] in these words belongs to one morpheme, there is phonological evidence which suggests that [au] belongs to two syllables whereas [ai] forms one syllable (see sections 3.6–3.7 below).

Finally, foreign morphemes seem to show a similar difference in frequency between [ai] and [au]. It is certainly difficult to delimit an ever-increasing number of morphemes of this type in Modern Japanese. However, the major source of foreign morphemes in Modern Japanese is English, where, as we saw in section 2.1 above, [ai] occurs in a much larger number of English words than [au]. Furthermore, there are several independent pieces of evidence that [au], but not [ai], tends to turn into a monophthong in a certain class of loanwords (sections 3.3–3.5 below). All these facts taken into consideration, it seems safe to assume that foreign morphemes, too, show an asymmetry between [ai] and [au], with the former appearing more frequently than the latter.

3.2. Vowel Coalescence and Historical Stability

Given the remarkable difference between [ai] and [au] with respect to their frequencies in Modern Japanese morphemes, one may quite naturally ask why such a difference is observed in the first place. This question can be answered at least in part by considering the history of the two vowel sequences in the language.

The complete lack of [au] in SJ morphemes may give the impression that it was absent in the inventory of vocalic phonemes in ancient or old Japanese. This impression turns out to be wrong if we study the history of SJ morphemes, however. There is evidence that Japanese

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had this particular vowel sequence in at least some SJ morphemes (Kindaichi (1976)). What happened then is that [au] underwent a sound change called vowel coalescence, whereby it changed into a monophthong corresponding to [o:] in Modern Japanese. This sound change took place at the end of Middle Japanese (in the Muromachi Period) or at the beginning of Early Modern Japanese (in the Sengoku and Edo Periods). The instances in (2) are taken from Kindaichi (1976: 159).

(2) [au] → [o:] ‘cherry tree’
[kau] → [ko:] ‘high,’ ‘fidelity’
[kjau] → [kjo:] ‘capital,’ ‘home town’

On the other hand, vowel coalescence did not occur obligatorily in morphemes containing [ai]. It did occur in casual speech at a later stage of Tokyo Japanese, where we now observe an alternation as shown in (3a) between careful and casual speech. This alternation is also observed in native Japanese words including those in (3b). However, this sound change did not occur in careful pronunciations in Tokyo Japanese, nor did it penetrate into Kyoto Japanese and many other dialects. In fact, the monophthongal pronunciation for the original [ai] is characteristic of casual speech in contemporary Tokyo Japanese (‘N’ stands for the moraic nasal).

(3) a. tai.gai ~ tee.gee ‘usually,’ siN.pai ~ siN.pee ‘worry,’
kyoo.dai ~ kyoo.dee ‘brother,’ dai.koN ~ dee.koN ‘radish’
b. i.tai ~ i.tee ‘painful, ouch,’ hai.ru ~ hee.ru ‘to enter’

Now what about native morphemes? A historical study of [ai] and [au] in native morphemes reveals a picture that is essentially identical to the one we saw above for SJ morphemes. As is well known, Japanese did not have any diphthongs or any tautomorphic vowel sequences at the beginning of its history. In the course of history, however, the language developed the two vowel sequences from /aCi/ and /aCu/ (‘C’ refers to any onset consonant) via consonant deletion processes called ‘i-onbin’ and ‘u-onbin,’ respectively (Komatsu (1981)). The history of these newly created vowel sequences is almost parallel to that of [ai]

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4 Vowel coalescence processes in Japanese, both historical and synchronic, follow a single rule whereby the resultant vowel inherits the value of [high] from the first element of the vowel sequence and the values of [low] and [back] from the second element. See Kubozono (1999b) for the details of this featural analysis.
and [au] in SJ morphemes. Namely, [au] changed into a monophthong via vowel coalescence, whereas [ai] remained intact except in very colloquial (and often slangish) speech. Let us first consider the examples that Katayama (1998) gives for adjective+suffix sequences.5

(4)  a. haya + i → hayai ‘fast’
    haya + u → hayau → hayoo
  b. taka + i → takai ‘high, tall’
    taka + u → takau → takoo

This asymmetry between [ai] and [au] can be extended to verbal morphology, where one finds a contrast between (5a) and (5b).

(5)  a. ahi + masu → aimasu ‘to meet (polite form)’ (no change)
    b. ahu + ta → auta → oota ‘met (past)’

One difference between native and SJ morphemes is that some instances of [au] were free from the effect of vowel coalescence in native morphemes. These exceptions are mostly in the final position of verbs, as shown by the examples in (6).

(6)  ahu → au → *oo ‘to meet’
    kahu → kau → *koo ‘to buy’

Despite this difference, the fact remains that [ai] has been quite stable in both native and SJ morphemes in the history of Japanese. In sharp contrast to this, [au] has undergone vowel coalescence into [o:] in all SJ morphemes and most native morphemes. Moreover, vowel coalescence affected [au] at an earlier period of history than [ai] in Tokyo Japanese, where the coalescence of [ai] into [e:] remains an optional rather than obligatory phonological process.

Having looked at the striking difference between [ai] and [au] with respect to their historical stability, it is worth pointing out that this difference can probably be extended to other vowel sequences. Generally, vowel sequences whose second member is [i] are more resistant than those ending in [u] to the historical process of vowel coalescence. Thus, [oi] and [ui] show considerable stability and turn into a monophthong only in casual pronunciations of adjectives in contemporary Japanese. On the other hand, their mirror-image counterparts, [eu] and [iu], almost obligatorily underwent coalescence. Some examples are

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5 Historically, all the words in the input arguably come from CVCV CVCV forms via consonant deletion: e.g. /hayasi/ → /hayai/, /hayaku/ → /hayau/.
given in (7).

(7) a. \([oi]\) sugoi \~ sugee ‘great,’ omosiroi \~ omosiree ‘funny,’
koi (no alternation) ‘carp, love’

\([ui]\) atui \~ atii ‘hot,’ tuitati (no alternation) ‘first day of the
month’

b. \([eu]\) → \([joː]\) teuteu → tyootyoo ‘butterfly,’ neu → nyoo
‘urine,’ keu → kyoo ‘today’

\([iu]\) → \([juː]\) iu → yuu ‘to say,’ riu → ryuu ‘dragon’

Again, the obligatory coalescence processes in (7b) took place earlier
than the optional processes in (7a) in the history of the language.
According to Kindaichi (1976: 46ff), the processes in (7b) occurred at
the end of Middle Japanese (in the Muromachi Period), almost at the
same time as the comparable process described in (2). The processes
in (7a), in contrast, took place in Early Modern Japanese (or in the Edo
Period).

While \([oi]\) and \([ui]\) developed in quite different ways from \([eu]\) and
\([iu]\), \([ei]\) and \([ou]\) did not show such a difference. In fact, both \([ei]\)
and \([ou]\) developed equally obligatorily into \([eː]\) and \([oː]\), respectively.
These developments are illustrated in (8). However, Kindaichi (1976:
161) notes that these two developments, too, show a time difference,
with \([ou]\) undergoing coalescence before \([ei]\) did (see also Takayama
(1992)).

(8) a. \([ei]\) → \([eː]\) eiyuu → eeyuu ‘hero’

b. \([ou]\) → \([oː]\) ou → oo ‘king’

In sum, vowel sequences ending in \([i]\) have been more or less stable
in the history of Japanese, whereas those ending in \([u]\) have shown a
striking tendency towards monophthongization. Moreover, vowel co-
alescence affected the former type of vowel sequences only after it
affected the latter type in the course of the history. These historical
facts seem responsible for the synchronic state of affairs discussed in
the preceding section, and indeed reinforce our argument that \([au]\) is
more marked than \([ai]\) in Japanese. Interestingly, it seems that Korean
has undergone a similar historical change, as we will see in section 4
below.

3.3. /aiʃ/ and /auʃ/ in Loanwords

In addition to the two types of evidence we have so far seen, there
are five other independent types of evidence for the relative markedness
of \([au]\) over \([ai]\). All of these come from a phonological or morpho-
logical analysis of loanwords. Two of them concern the fate of English [ai] and [au] as they are borrowed into Japanese. Let us first consider the fact pointed out by Katayama (1998).

Katayama (1998) observes that [ai] and [au] before a schwa [ə] are borrowed in different phonological forms in Japanese. They are illustrated in (9a, b).

(9)  a. /taie/ ‘tyre’ → [tai. ja], /faiə/ ‘fire’ → [fai. ja:], /baiə/ ‘buyer’ → [bai. ja:]
    b. /taue/ ‘tower’ → [ta. wa:], /sauə/ ‘sour’ → [sa. wa:],
       /pauə/ ‘power’ → [pa. wa:], /auə/ ‘hour’ → [a. wa:],
       /flauə/ ‘flower’ → [hu. ra. wa:]

The vowel sequence [aiə] turns into a bisyllabic form [ai. ja] with the palatal semivowel/glide [j] added as the onset of the second syllable. This glide insertion is an independent process that inserts [j] in an onsetless syllable preceded by a non-back vowel: e.g. /pi. a. no/ → [pi. ja. no] ‘piano.’ On the other hand, the vowel sequence [auə] undergoes the deletion of [u] to yield the form [a. wa:]. In this case, the labial glide [w] is put before a schwa by an independent process that inserts a labial glide in an onsetless syllable preceded by a back vowel (Kubozono (2002a)). In this latter case, too, the resultant form is bisyllabic, with [w] functioning as the onset of the second syllable.

However, the crucial difference between the two cases in (9) is evident. In the case of [aiə], both [a] and [i] survive in the resultant borrowed form, whereas [u] is apparently lost in the case of [auə]. Of course, [au] appears almost as freely as [ai] in other phonological contexts, as exemplified in (10). However, it is clear that Japanese somehow avoids creating [au] in the phonological context in (9). There is no comparable constraint on the occurrence of [ai].

(10)  [au. to] ‘out,’ [rau. do] ‘loud,’ [pau. da:] ‘powder’

Long vowels also seem to shorten in loanwords when they appear before a schwa: i.e. [V:ə] → [Və]. This will be equivalent to the shortening of [au] to [a] in (9b).
Another piece of evidence suggesting the instability of [au] in the loanword phonology of Japanese is found in the borrowing of [ain] and [aun] sequences. It is known that Japanese syllables are strongly constrained with respect to their maximal weight (Kubozono (1995, 1999a)). In particular, they are subject to the general constraint prohibiting superheavy, i.e. trimoraic, syllables. This constraint, which we call 'trimoraic syllable ban,' applies specifically to long vowels and diphthongs as they appear with a coda consonant. If the original word contains a syllable consisting of a long (tense) vowel or diphthong plus a coda nasal, this syllable is expected to yield a trimoraic syllable in Japanese with the nasal translated as a moraic coda nasal (N). This process is constrained by the syllable weight constraint, which forces trimoraic sequences into bimoraic ones. The most orthodox way to achieve this goal is to shorten the vocalic part, i.e. to shorten long vowels and to delete the second element of diphthongal vowel sequences. This shortening/deletion process, which Lovins (1975) described as 'pre-nasal vowel shortening,' is illustrated in (11). This process is equivalent to the well-known phenomenon of closed syllable vowel shortening in English and other languages (Kubozono (1995)).

(11) a. English /aun/ → Japanese /aN/
   gu.raN.do ‘ground,’ faN.dee.sy.on ‘foundation,’
   me.rii.go.o.raN.do ‘merry-go-round,’ waN.daN ‘one down,’
   tuu.daN ‘two-down,’ waN.baN ‘one bound (ground ball)
   (in baseball)’

b. English /e:n/ → Japanese /eN/
   reN.zi ‘range,’ tyeN.zi ‘change,’ a.reN.zi ‘arrange,’
   su.teN.re.su ‘stainless,’ eN.zye.ru ‘angel,’ keN.bu.ri.dzi
   ‘Cambridge’

c. English /i:n/ → Japanese /iN/
   gu.riN.pii.su ‘green peas,’ ma.siN ‘machine,’ ku.iN.bii
   ‘queen bee’
   English /o:n/ → Japanese /oN/
   koN.bii.hu ‘corned beef’

The shortening process sketched in (11) is not a recent finding. Lovins (1975) described it over two decades ago and Kubozono (1994, 1995) proposed to explain it in terms of a constraint on the maximal weight of the syllable. However, these previous studies apparently overlooked an interesting asymmetry between /aiN/ and /auN/. Namely, there is no
instance as far as I examined that involves shortening of /aiN/ into /aN/; /aiN/ is invariably manifested as such as shown in (12).⁷

(12) saiN ‘sign,’ raiN ‘line, The Rhine,’ raiN.ga.wa ‘River Rhine,’ de.zaiN ‘design,’ ko.kaiN ‘cocaine’

This strongly contrasts with the fact that /auN/ is shortened to /aN/ in many instances including those in (11a). There are exceptions to (11a), as we shall see shortly below, but this does not undervalue the contrastive behavior between /aiN/ and /auN/. In fact, [au] patterns with long vowels and tends to become a short monophthong. This means that the second element of [au] behaves as if it were segmentally invisible when preceding a moraic nasal. This asymmetry between [ai] and [au] reinforces our argument that [au], but not [ai], is unstable in contemporary Japanese.

3.5. Stability in Word Formation

A fifth piece of evidence for the markedness of [au] over [ai] in Japanese stems from yet another fact showing the stability of /aiN/ over /auN/. This evidence comes from a phonological analysis of the morphological process of compound truncation.

The most productive pattern of compound truncation in contemporary Japanese is to form a four-mora word by combining the initial two moras of one component word with those of the other (Ito (1990), Ito and Mester (1995), Kubozono (1999a, 2002b)).⁸ Some examples are given in (13), where ‘L’ and ‘H’ stand for light (monomoraic) and heavy (bimoraic) syllables, respectively, and [ ] denotes a foot boundary.

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⁷ This does not mean that /aiN/ is accepted as a trimoraic syllable in Japanese. A careful analysis of the accentual behavior of /aiN/ suggests that it actually consists of two syllables with a syllable boundary within [ai], i.e. /a/ + /iN/, in Tokyo Japanese (see Kubozono (1995, 1999a) for details). This analysis can be further corroborated by evidence from Kagoshima Japanese, where /aiN/ clearly splits into two syllables, /a/ + /iN/ (Kubozono (2004)).

⁸ Equally productive is the pattern whereby one component of a compound expression is entirely omitted with the other component remaining intact: e.g. kontakuto renzu → kontakuto ‘contact lens,’ keitai denwa → keitai ‘mobile phone,’ suupaa maaketto → suupaa ‘supermarket’ (Kubozono (2003b)).
(13) a. LL+LL  \text{se.ku.sya.ru ha.ra.su.meN.to $\rightarrow$ [se.ku][ha.ra]}
   ‘sexual harassment’
 b. LL+H  \text{po.ket.to moN.su.taa $\rightarrow$ [po.ke][moN]}
   ‘Pokèmon, pocket monster’
 c. H+LL  \text{haN.gaa su.to.rai.ki $\rightarrow$ [haN][su.to]}
   ‘hunger strike’
 d. H+H  \text{haN.bun doN.ta.ku $\rightarrow$ [haN][doN]}
   ‘a half day off (= a half + holiday)’

As can be seen from (13), the truncation process in question is basically independent of syllable structure. That is, the utmost requirement is to yield a four-mora template—or, equivalently, a template consisting of two bimoraic feet. This default pattern, however, admits several types of exceptions, one of which concerns /auN/ sequences (Kubozono (2003b)). As suggested above, there are quite a few exceptions to the shortening process in (11a). Some are given in (14), where syllable boundaries are not specified because of potential ambiguity.9

(14) sauNdo ‘sound,’ mauNten ‘mountain,’ kauNsiru ‘council,’ kauNto ‘count’

These /auN/ sequences exhibit exceptional behavior in compound truncation. The rule sketched in (13) predicts that the words in (14) leave the initial two moras in this morphological process: e.g. /sauNdo/ $\rightarrow$/sau/, /mauNten/ $\rightarrow$/mau/. However, what is actually observed is the pattern shown in (15), where the moraic nasal (N) is retained instead of the second half of [au]. This pattern is obtained whether /auN/ appears in the first component (15a) or in the second component (15b) (cf. Kuwamoto (1998b)).10

(15) a. sauNdo torakku $\rightarrow$ [saN][tora] ‘sound track’
 b. buruu mauNten $\rightarrow$ [buru][maN] ‘Blue Mountain’
   buritissyu kauNsiru $\rightarrow$ [buri][kaN] ‘British Council’
   noo kauNto $\rightarrow$ [noo][kaN] ‘no count (in baseball)’

While /auN/ exhibits an irregular pattern of truncation, /aiN/ and

9 It is not clear yet what triggers pre-nasal shortening of /auN/ as in (11a) and what blocks this same process in the words in (14). All one can say with some certainty is that pre-nasal shortening tends to affect /auN/ sequences in relatively long words and in old (as opposed to recent) borrowings.
10 Kuwamoto (1998b) makes the same observation but fails to notice that /auN/ behaves differently from /aiN/.
/oiN/ do not show any such irregularity. There are not many truncated compounds that involve /aiN/ or /oiN/, but those that do follow the regular pattern by retaining the initial two moras of the trimoraic sequences. This is exemplified in (16).

(16) a. doNto maiNdo → [doN][mai], *[doN][maN] ‘Don’t mind’
   b. zyoiNto beNtyaa → [zyoi][beN], *[zyoN][beN] ‘joint venture (business)’

Note here that the shortening of [au] to [a] in (15) is an entirely context-dependent phenomenon. [au] follows the regular truncation pattern in (13) just as [ai] does when it is not followed by a moraic nasal. As shown in (17), both [ai] and [au] retain their second mora when they appear before a syllable boundary.

(17) a. mai.ku.ro koN.pyuu.taa → [mai][koN] ‘micro computer’
   poo.to ai.raN.do → [poo][ai] ‘Port Island (in Kobe)’
   b. au.to do.rop.pu → [au][do.ro] ‘outdrop (in baseball)’

In sum, the contrast between (15) and (16) suggests that the second mora of /auN/, i.e. /u/, is invisible to the morphological rule of compound truncation. Interestingly, long vowels and geminate obstruents (or moraic obstruents) often show a similar effect of invisibility in the same morphological process. This is illustrated in (18) and (19), respectively, where forms with an asterisk represent an unattested regular form (Kubozono (1999a, 2002b, 2003a), Kuwamoto (1998a, b), Ito (2000)).11,12

(18) a. paa.so.na.ru koN.pyuu.taa → [pa.so][koN], *[paa][koN] ‘personal computer’
   suu.paa koN.pyuu.taa → [su.paa][koN], *[suu][koN] ‘super computer’
   mee.ru to.mo.da.ti → [me.ru][to.mo], *[mee][to.mo] ‘e-mail friend’

11 It may be noticed that both long vowels and geminate obstruents exhibit different patterns of truncation depending on the location where they appear. Namely, when they appear in the medial position of truncated forms, a following mora tends to compensate for their shortening (18a)/(19a), whereas no such compensation occurs when they appear in the final position (18b)/(19b) (Kubozono (2002b, 2003b)).

12 Long vowels and geminate obstruents do sometimes follow the regular truncation pattern: e.g. waa.do pu.ro.se.saa → [waa][pu.ro] ‘word processor,’ pa.to.roo.ru kaa → [pa.to][kaa] ‘patrol car = police car,’ a.ru.koo.ru tyuu.do.ku → [a.ru][tyuu] ‘alcoholism’; daN.zeN to.pu → [daN][to.tu] ‘by far the best.’
b. daN su paa.tii → [daN]pa, *[daN][paa] ‘dance party’

(19) a. bak.ku teN.kai → [baku][teN], *[bar][teN]
‘backward rotation (in gymnastics)’
a.me.ri.kaN hut.to.boo.ru → [a.me][hu.to], *[a.me][hut]
‘American football’
b. po.te.to tip.pu.su → [po.te]ti, *[po.te][tip] ‘potato chips=fried potato’

As mentioned in the preceding section, [au] and long vowels show the same behavior in pre-nasal vowel shortening, i.e. they omit their second component. It is indeed interesting that [au] patterns with long vowels rather than with [ai] in compound truncation, too.

3.6. Accentual Phenomena

The same type of asymmetry between [ai] and [au] is observed in accentuation, too. In Tokyo Japanese, compound accent (CA) usually falls on the final syllable of the first member if the second member is one or two moras long (Akinaga (1981)). My preliminary analysis suggests that the two vowel sequences in question show different patterns in this accentuation. If the first member ends in [ai], the CA usually falls on [a], as illustrated in (20a). This suggests that [ai] belongs to one and the same syllable and, hence, that it is a diphthong. If the first member ends in [au], on the other hand, the CA docks on [u] rather than [a]. This is exemplified in (20b).

(20) a. másai + zóku → masái-zoku ‘Masai, clan; the Masais’
b. donau + kawá → donau-gawa ‘The River Donau (Danube)’

Some speakers seem to place the CA on [i] in (20a), but no speaker puts the CA on [a] in (20b). This contrast seems to suggest that [ai] tends to form a unified syllable in loanwords, whereas [au] tends to constitute two separate syllables. Interestingly, the same syllabification holds in Kagoshima Japanese, a dialect spoken in the south of Japan, which is syllable-based rather than mora-based (like Tokyo Japanese). In this dialect, loanwords are usually accented, i.e. bear a high tone, on the penultimate syllable. That [ai] but not [au] functions as a diphthong in the accent system of Kagoshima Japanese can be fully substantiated by the data in (21), where high-toned syllables are capitalized (Kubozono (2004)).

(21) a. [ai] FAI.ru ‘file,’ a.ri.BAI ‘alibi,’ MA.sai ‘The Masais,’
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a.ru.BAI.to ‘Arbeit, part-time work’


Interestingly, Kagoshima Japanese shows a similar syllable structure for [au] in native words, too. As noted in section 3.1, [au] appears in a certain number of morphemes (or morpheme concatenations) in Modern Japanese. In Kagoshima Japanese, [a] and [u] bear different tones in verbal forms such as au ‘to meet’, mukau ‘to head (for some place),’ suggesting that [a] and [u] belong to two different syllables: e.g. /a.u/ and /mu.ka.u/. This provides additional evidence that [au] does not form a diphthong in Japanese.

3.7. Chants in Baseball Cheering

As a final piece of evidence for the asymmetry between [ai] and [au], let us consider the structure of baseball phrases chanted by Japanese baseball fans. According to Tanaka (1999), the phrase that baseball fans chant to cheer their favorite players consists of three musical notes plus a following pause. In the normal chant, this phrase corresponds to the player’s (usually batter’s) name. If the player’s name consists of three moras, each mora is associated with a musical note irrespective of the syllable structure involved.

(22) \[\begin{array}{cccc}
\mid & \mid & \mid & \mid & \mid & \mid \\
ma & tu & i & sa & ta & N & sa & N & ta \\
\end{array}\]

‘Matsui’ ‘Satan’ ‘Santa’

This mora-to-note correspondence is broken if the player’s name consists of four or more moras. The basic rule in such cases is to assign the name’s last syllable to the last musical note. Thus, the last note corresponds to the last syllable of the player’s name, whether it is a heavy syllable as in (23a) or a light one as in (23b).

(23) a. \[\begin{array}{cccc}
\mid & \mid & \mid & \mid & \mid \\
i & ti & roo & o & ti & ai \\
\end{array}\]

‘Ichiro’ ‘Ochiai’

b. \[\begin{array}{cccc}
\mid & \mid & \mid & \mid & \mid & \mid & \mid \\
a & ka & mu & ra & zu & ree & ta & sa & N & ta & na \\
\end{array}\]

‘Nakamura’ ‘Zureta’ ‘Santana’
According to Tanaka (personal communication), [ai] and [au] display different patterns with respect to this syllable-to-note association rule. Namely, [ai] is assigned to the last musical note, as shown in (23a), but [au] splits into two, with [a] and [u] being associated with different notes. This fact, which is illustrated in (24), indicates that [au] is processed as a sequence of two syllables.

(24)  \[ \text{ri Nda u} \]
     \[ \text{`Lindau'} \]

4. [ai]-[au] Asymmetry in Other Languages

In the preceding section, we have seen seven independent phenomena each of which shows an asymmetry between [ai] and [au] in Japanese. All these phenomena reveal the marked behavior of [au] as opposed to [ai]. In the phenomena discussed in sections 3.2–3.5, [au] behaves as a very unstable vowel sequence and undergoes vowel coalescence or shortening (to [a]). In other phenomena (sections 3.6–3.7), [au] surfaces without any segmental change, but it does not belong to one unified syllable. In either case, [au] resists being processed as a diphthong. This contrasts sharply with the behavior of [ai], which consistently functions as a diphthong in the language. All in all, [ai] forms a much better syllable nucleus than [au] in Japanese phonology.

Given this asymmetry between [ai] and [au], one naturally wonders why Japanese exhibits such an asymmetry at all. One way of tackling this question is to ask if the asymmetry is specifically observed in Japanese or if it is observed in a wide range of languages. In this section, I will explore the second possibility and describe some languages that do display a very similar [ai]-[au] asymmetry.

4.1. Korean

According to Ahn and Iverson (2004), Middle Korean (15th century) had six diphthongs: [ii], [ui], [oi], [oi], [ai] and [oii]. Interestingly, all of these end in [i]. Although it is not clear whether Old Korean had [au], [eu] and [iu], it is interesting that tautosyllabic vowel sequences ending in [u] were totally absent in the vowel inventory of Middle Korean. In other words, Middle Korean shows a striking asymmetry whereby all diphthongs end in [i] and not in [u]. This is comparable to the situation of Early Modern Japanese, where every diphthong ended
in [i]. In both languages, [ai] and other vowel sequences ending in [i] constitute very good syllable nuclei, whereas vowel sequences ending in [u] such as [au] and [iu] do not.

Korean differs from Japanese in that it now has no diphthong. Of the six diphthongs permitted in Middle Korean, only [ii] survived in the 18th-19th century Korean. This last diphthong has disappeared, too, with the result that no diphthong is present in the vowel inventory of present-day Korean. In contrast, Modern Japanese still preserves [ai], [oi] and [ui], which alternate with monophthongal forms in casual speech. In other words, monophthongization of [ai], [oi] and [ui] was obligatory in Korean, while it remains an optional process in Japanese. In historical terms, this difference between Korean and Japanese can be interpreted as suggesting that the former is a few centuries ahead of the latter in the process of monophthongization. In synchronic terms, the same difference indicates that Korean is subject to a constraint prohibiting diphthongs (*DIPHTHONG or *COMPLEX) in a more stringent way than Japanese.

4.2. Romanian

According to Donca Steriade (personal communication), Romanian exhibits two types of asymmetry between [ai] and [au]. First, [au] always constitutes two syllables in word-medial position, while [ai] can be tautosyllabic in the same word position if [i] is stressless. This is illustrated in (25). This asymmetry disappears in absolute word-final position, where both [ai] and [au] appear within a syllable, as illustrated in (26).

(25) a. scaune [ská.u.ne] ‘chairs,’ caută [ká.u.ta] ‘they look for’
   b. haine [hái.ne] ‘clothes,’ haită [hái.ta] ‘pack (of wolves)’

(26) a. au [áu] ‘they have,’ visau [ví.sau] ‘they were dreaming’
   b. cai [káí] ‘horses,’ visai [ví.sai] ‘you (singular) were dreaming,’ malai [má.lai] ‘corn, maize,’ balai [bá.lai] ‘blond’

A second type of asymmetry is observed when the vowel sequences in question occur before a word-final consonant (_C#). In this context, [au] always splits into two syllables, while [ai] and other vowel sequences ending in [i] are accommodated within a single syllable. This is exemplified in (27a, b).


What (25) and (27) have in common is that [ai] tends to constitute a syllable nucleus, whereas [au] tends to refuse this integration. This is a situation similar to the one described in sections 3.6–3.7, where it was pointed out that [ai] counts as one syllable and [au] as two in Japanese. In both Romanian and Japanese, [ai] constitutes a good syllable nucleus, while [au] tends to form two nuclei, that is, two syllables.

5. Conclusion

In this paper we have looked at many independent phenomena in which [ai] and [au] exhibit different degrees of markedness. In Japanese and English alike, [ai] occurs much more frequently than [au]. This asymmetry can be related to phonotactic constraints on the two diphthongs in English, where [ai] combines with a wider range of coda consonant than [au]. I argued that this phonotactic asymmetry can be largely attributed to the historical fact that Middle English /u:/ failed to diphthongize into Modern English [au] in certain phonotactic environments (section 2). On the other hand, the relatively low frequency of [au] in Modern Japanese can be accounted for at least in part by the historical fact that [au] has tended to coalesce into [o:], whereas [ai] has remained more or less stable in the course of history (section 3.2). We also saw a historical fact that [au] underwent vowel coalescence at an earlier stage than [ai]. Furthermore, a careful analysis of the phonological structure of loanwords in Japanese has uncovered several independent phenomena in which [au] is a rather unstable vowel sequence turning very easily into a monophthong via vowel shortening or deletion (sections 3.3–3.5). There are certain cases where [au] surfaces as such, but in such cases the vowel sequence is processed as a heterosyllabic vowel sequence rather than as a tautosyllabic sequence, i.e. diphthong (sections 3.6–3.7). In all these cases, [au] is not a favored syllable nucleus.

This paper has raised as many questions as it has solved. The most important question for future work concerns the nature of the markedness of [au] over [ai]. In the final part of this paper I have hinted that the [ai]-[au] asymmetry is not restricted to Japanese phonology. We must pursue further cross-linguistic studies and confirm this point using many other languages.
It is also important to ask if an asymmetry between [ai] and [au] can be extended to other vowel sequences as well. I have hinted in passing that the relative markedness of [au] over [ai] may reflect a more general difference in markedness between vowel sequences ending in [u], e.g. [iu], [eu], and those ending in [i], e.g. [ui], [oi]. This seems to hold at least in Japanese, but we should ask if the same is true of other languages.

If it turns out that [au], [eu] and [iu] tend to form a less harmonic syllable nucleus than [ai], [oi] and [ui] in many languages, we can then ask ourselves why that should be the case. We could tackle this question from various viewpoints, particularly from articulatory, acoustic and perceptual points of view. It will be interesting, for example, if we can experimentally show that [a] and [u] are perceptually more similar to each other than [a] and [i] are to each other, and therefore not easily tolerated in the same syllable, unless they coalesce into one vowel. This and other questions remain open for future work.

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