ON THE MARKEDNESS OF DIPHTHONGS

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[SUMMARY]

This paper argues for markedness distinctions among diphthongs, especially between [ai] and [au], which presumably represent the two most common diphthongs across languages. It is demonstrated that [au] is much more marked than [ai] in both Japanese and English. In Japanese, [au] appears much less frequently than [ai] in all the three kinds of morphemes—native, Sino-Japanese and foreign—and, moreover, shows much less stability both historically and synchronically, especially in foreign words. There is also evidence which suggests that all diphthongs ending in [u], *i.e.* [au], [eu], [iu] and [ou], are relatively more marked in Japanese than their mirror-image counterparts, *i.e.* [ai], [oi], [ui] and [ei]. The second half of the paper discusses evidence from English, which reveals that [au] appears much less frequently and in more restricted phonotactic environments than [ai].

1. INTRODUCTION

`Markedness' is one of the key notions in contemporary phonology, especially in the constraint-based theory called `Optimality Theory' (Prince and Smolensky 1993). This notion has been shown to play a pivotal role in generalizing both segmental and prosodic phenomena in many languages. For instance, syllables without an onset consonant is more marked than those with an onset: any language with an onsetless syllable has a syllable with an onset, too, but not vice versa (Jakobson 1968). Likewise, syllables with a coda consonant are more marked than those without a coda; consonant clusters (CC, CCC) are more marked than a single consonant both in the onset and coda positions; [a] is the least marked vowel as it occurs in virtually all human languages, etc. However, markedness relationship or hierarchy of this kind has not been clearly defined for different types of diphthongs. Diphthongs are claimed to be more marked than monophthongs, to be sure, but it is not clear whether a certain diphthong is more marked than others and, if so, on what grounds such a markedness distinction holds.

The primary goal of this article is to argue for a markedness distinction among diphthongs, 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 Japanese and English, 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. After defining the notion `diphthong' in section 2, section 3 is devoted to an analysis of Japanese, followed by a discussion of evidence from English in section 4. The final section (section 5) summarizes the main points and some remaining problems for future work.

2. DIPHTHONGS

Diphthongs refer to a tautosyllabic sequence of two vowels of different qualities. One question that always arises when we discuss this type of vowel is where we can draw a line between `diphthongs' as defined in this way and heterosyllabic vowel sequences, or sequences of any two vowels that occur across a syllable boundary.

At least three criteria are used for the definition of diphthongs in general, one being morphological and the other two phonological. The morphological criterion is that two vocalic elements must be within a morpheme rather than across two morphemes in order to form a diphthong. Thus [ai] in the word /ai/ `love' is entitled to form a diphthong, whereas [ai] in the compound noun /ha+isya/ `tooth, doctor; dentist' is not. Of the two phonological criteria, one concerns the sonority of the two vowels in question. Given a sequence of two vowels, V_1 and V_2, V_1 must be at least as sonorous as V_2 to form a diphthong. Stated conversely, V_1 and V_2 belong to different syllables and do not form a diphthong if V_2 is more sonorous than V_1, *e.g.* [ia], [oa]. Potential exceptions to this are cases where the first vowel becomes a glide, *e.g.* [ia] → [ja], as well as cases where the second vowel becomes a schwa, *e.g.* [ia] → [i].

The other phonological criterion is related to word accent and specifically applies to Japanese. The accent assigned to V_2 by any quantity-sensitive accent rule usually shifts to V_1 if the two vowels are within a single syllable, *i.e.*, if they form a diphthong. This contrasts with the case where the accent assigned to V_2 remains intact if the two vowels are across a syllable boundary. This interpretation is based on the general observation that accent falls on the nuclear vowel of the syllable, rather than on the mora originally designated as the accent locus by mora-counting accent rules (McCawley 1978, Kubozono 1999a).

Although matters may be more complicated in some cases, the three criteria stated above seem to be sufficient when we discuss the two diphthongs [ai] and [au] in Japanese. Generally, both [ai] and [au] satisfy the two phonological requirements as long as the two vowels are within a single morpheme (see Note 5 below for some exceptional cases). Other vowel sequences such as [oi], [ei], [eu] and [ou] can also be interpreted as constituting a diphthong as long as they are tautomorphemic. [iu] and [ui] may be somewhat more ambiguous because their components, [i] and [u], are just as sonorous as each other. These vowel sequences must be tested by accent rules with respect to their syllabic status.

3. JAPANESE

Japanese provides several independent pieces of evidence that suggest that [au] is more marked than [ai]. As far as I know, the first person to note this asymmetry was 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 [ai] while turning [au] into [a] in the sequence [au]. Second, there is no Sino-Japanese (SJ) morpheme containing the diphthong [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 diphthongs 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 two sections (3.3 and 3.4) analyze the asymmetry between [ai] and [au] in the loanword phonology of contemporary Japanese. This will be followed by an analysis of the morphological process of compound truncation (section 3.5), which also reveals a striking difference between the two diphthongs with respect to their stability.

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 diphthongs occur in Japanese morphemes. In modern Tokyo Japanese, both diphthongs occur, but [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. [ai] is generally more frequent than [au] irrespective of the type of consonant that precedes the diphthongs. The only exception to this general tendency is the case where the word begins with the diphthong, *i.e.*, with an onsetless syllable containing the diphthong: seven morphemes begin with [ai], *e.g. ai* `indigo (plant)', as opposed to nineteen morphemes which begin with [au], *e.g. au* `to meet'.

Foreign morphemes, which constitute a third class of morphemes in Japanese, are difficult to analyze in the same way largely because it is difficult to delimit an ever-increasing number of morphemes of this type in modern Japanese. On the other hand, there is an independent fact that [ai] occurs in a much larger number of English words than [au] (see section 4.1) and, moreover, foreign morphemes in modern Japanese come most predominantly from English. Furthermore, there is evidence, as we will see in sections 3.3-3.5 below, that [au], but not [ai], tends to turn into a monophthong in a certain class of loanwords. 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 diphthongs in the language.

The complete lack of [au] in SJ morphemes may give the impression that this diphthong was absent in the inventory of vocalic phonemes in old Chinese from which Japanese borrowed SJ morphemes. This impression turns out to be wrong if we study

the history of SJ morphemes, however. There is evidence that Japanese had this particular diphthong in at least some SJ morphemes (Kindaichi 1976). What happened then is that [au] underwent a sound change called vowel coalescence, which changed the diphthong into a monophthong corresponding to [o□] in modern Japanese.[1)] This sound change took place at the end of Middle Japanese (in Muromachi Era) or at the beginning of early modern Japanese (in Sengoku and Edo Era). The instances in (1) are taken from Kindaichi (1976: 159).

(1) [au] → [o□] `cherry tree' (**桜**)
[kau] → [ko□] `high' (**高**), `fidelity' (**孝**)
[kjau] → [kjo□] `capital' (**京**), `home town' (**郷**)

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 (2a) between careful and casual speech. This alternation is also observed in native Japanese words including those in (2b). 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.

(2) 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 at the beginning of its history. In the course of history, however, the language developed the two diphthongs 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 diphthongs is almost parallel to that of [ai] 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.[2)]

(3) 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 (4a) and (4b).

(4) 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 (5).

(5) 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 the two diphthongs with respect to their historical stability, it is worth pointing out that this difference can probably be extended to other diphthongs. Generally, diphthongs 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 given in (6).

(6) a. [oi] sugoi～sugee `great', omoiroi ～omoiree `funny'
koi (no alternation) `carp, love'
[ui] atui～atii `hot', tuitati (no alternation) `first day of the month'
b. [eu] → [jo□] teuteu → tyootyoo `butterfly',
neu → nyoo `urine', keu → kyoo `today'
[iu] → [ju□] iu → yuu `to say', riu → ryuu `dragon'

Again, the obligatory coalescence processes in (6b) took place earlier than the optional processes in (6a) in the history of the language. According to Kindaichi (1976: pp.46ff), the processes in (6b) occurred at the end of Middle Japanese (in Muromachi Era), almost at the same time as the comparable process described in (1). The processes in (6a), in contrast, took place in early modern Japanese (or in Edo Era).

While [oi] and [ui] developed in quite different ways from [eu] and [iu], [ei] and [u] did not show such a difference. In fact, both [ei] and [ou] developed equally obligatorily into [e□] and [o□], respectively. These developments are illustrated in (7). However, Kindaichi (1976:161) suggests that these two developments, too, show a time difference, with [ou] undergoing coalescence before [ei] did.

(7) a. [ei] → [e□] eiyuu → eeyuu `hero'
b. [ou] → [o□] ou → oo `king'

In sum, diphthongs 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 coalescence affected the former type of diphthongs 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.

To go one step further, the markedness of [au] over [ai] may be related to the idea that the monophthong [u] is more marked than the monophthong [i] cross-linguistically. This latter idea can be substantiated statistically by the UCLA Phonological Segment Inventory Database (UPSID), which shows that most two-vowel systems in world languages consist of [a] and [i] rather than [a] and [u]. Moreover, it is also in accordance with Stevens's (1989) claim that vowels [a] and [i] are the two most acoustically stable vowels because they represent anchor points in the vocal tract.[3)] This potential link between the markedness of diphthongs and that of monophthongs will be an interesting topic to pursue.

3.3. Glide formation and synchronic stability

In addition to the two types of evidence we have so far seen, there are three other independent types of evidence for the relative markedness of [au] over [ai], all of which come from loanword phonology, or a phonological 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 (8a,b).

(8) a. /taiə/ `tyre' → [tai.ja]
/faiə/ `fire' → [fai.jaː]
/baiə/ `buyer' → [bai.jaː]
b. /tauə/ `tower' → [ta.waː]
/sauə/ `sour' → [sa.waː]
/pauə/ `power' → [pa.waː]
/auə/ `hour' → [a.waː]
/flauə/ `flower' → [hu.ra.waː]

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. On the other hand, the vowel sequence [auə] undergoes the deletion of [u] to yield the form [a.waː]—or, alternatively, [u] is weakened to become the velar glide [w]. 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 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 (9). However, it is clear that Japanese somehow avoids creating [au] in the phonological context in (8). There is no comparable constraint on the occurrence of [ai].[4)]

(9) [au.to] `out', [rau.do] `loud', [pau.daː] `powder'

3.4. Trimoraic syllable ban and synchronic stability

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 nasal (N). This process is constrained by the syllable weight constraint, which forces trimoraic sequences into bimoraic sequences. The most orthodox way to achieve this goal is to shorten the vocalic part of the sequences, *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 `prenasal vowel shortening', is illustrated in (10). This process is equivalent to the well-known phenomenon of closed syllable vowel shortening in English and other languages (Kubozono 1995).

(10) a. English /aun/ → Japanese /aN/
gu.raN.do `ground', faN.dee.syon `foundation',
me.rii.goo.raN.do `merry-go-round', waN.daN `one down',
tuu.daN `two-down', waN.baN `one bound (ground ball)' (in baseball)

b. English /ein/ → Japanese /eN/
reN.zi `range', tyeN.zi `change', a.reN.zi `arrange', su.teN.re.su `stainless',
eN.zye.ru `angel', keN.bu.rid.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 (10) is not a recent finding. Lovins (1975) described it over two decades ago and Kubozono (1993, 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 (11).[5)]

(11) 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 (10a). There are exceptions to (10a), as we shall see shortly below, but this does not undervalue the contrastive behaviour 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 an unstable diphthong in contemporary Japanese.

3.5. Stability in word formation

Our final evidence for the markedness of [au] over [ai] in Japanese stems from yet another fact showing the stability of /CaiN/ over /CauN/. This final 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, forthcoming).[6] Some examples are given in (12), where `L' and `H' stand for light (monomoraic) and heavy (bimoraic) syllables, respectively, and [ ] denotes a foot boundary.

(12) a. LL+LL
se.ku.sya.ru ha.ra.su.meN.to → [se.ku][ha.ra] `sexual harassment'
b. LL+H
po.ket.to moN.su.taa → [po.ke][moN] `Poke□mon, pocket monster'
c. H+LL
haN.gaa su.to.rai.ki → [haN][su.to] `hunger strike'
d. H+H
haN.bun doN.ta.ku → [haN][doN] `a half day off (= a half + holiday)'

As can be seen from (12), 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. As suggested above, there are quite a few exceptions to the shortening process in (10a). Some are given in (13), where syllable boundaries are not specified because of potential ambiguity.[7]

(13) sauNdo `sound', mauNten `mountain', kauNsiru `council', kauNto `count'

These /auN/ sequences exhibit exceptional behaviour in compound truncation. The rule sketched in (12) predicts that the words in (13) leave the initial two moras in this morphological process: *e.g.* /sauNdo/ → /sau/, /mauNten/ → /mau/. However, what is actually observed is the pattern shown in (14), where the moraic nasal (N) is retained instead of the second half of the diphthong [au]. This pattern is obtained whether /auN/ appears in the first component (14a) or in the second component (14b) (cf. Kuwamoto 1998b).[8]

(14) a. sauNdo torakku → [saN][tora] `sound track'
b. buruu mauNten → [buru][maN] `Blue Mountain'
buritissyu kauNsiru → [buri][kaN] `British Council'
noo kauNto → [noo][kaN] `no count (in baseball)'

While /auN/ exhibits an irregular pattern of truncation, /aiN/ and /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 (15) .

(15) 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 (14) is a phenomenon entirely dependent on a phonological context. This diphthong follows the regular truncation pattern in (12) just as [ai] does when it is not followed by a moraic nasal. As shown in (16), both [ai] and [au] retain their second mora when they appear before a syllable boundary.

(16) 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 (14) and (15) 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 (17) and (18), respectively, where forms with an asterisk represent an unattested regular form (Kubozono 1999a, in press, forthcoming; Kuwamoto 1998a/b, Ito 2000).[9), 10)]

(17) a. paa.so.na.ru koN.pyuu.taa → [pa.so][koN], *[paa][koN] `personal computer'
suu.paa koN.pyuu.taa → [su.pa][koN], *[suu][koN] `super computer'
mee.ru to.mo.da.ti → [me.ru][to.mo], *[mee][to.mo] `e-mail friend'
b. daN.su paa.tii → [daN]pa, *[daN][paa] `dance party'
te.re.hoN kaa.do → [te.re]ka, *[te.re][kaa] `phone card'

(18) a. bak.ku teN.kai → [baku][teN], *[bat][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 behaviour 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.

4. 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.

4.1. 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 bnger. Although it is unclear why [au] is so rare in long words, the overall discrepancy between the two diphthongs is evident.

Table 1	1-syllable word	2-syllable word	3-syllable word	4-syllable word
[ai]	254	603	522	287
[au]	108	237	71	12

4.2. Phonotactic restrictions

Another interesting discrepancy, which seems to account for the asymmetry in Table 1 at least to some extent, concerns the 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 cooccurrence restriction for the two diphthongs in word-final position: /---/ means the absence of an appropriate word.

Table 2 Cooccurrence restrictions between the diphthong and the following consonant

	/-p/	/-t/	/-k/	/-b/	/-d/	/-g/
/ai/	ripe	right	like	bribe	ride	---
/au/	---	bout	---	---	loud	---

	/-f/	/-□/	/-s/	/-□/	/-v/	/-□/	/-z/	/-□
/ai/	rife	blithe	rice	---	live	lithe	realize	---
/au/	---	mouth	mouse	---	---	mouthe	rouse	---

	/-m/	/-n/	/-□/	/l/	/r/	/-t□/	/-d□/
/ai/	time	rine	---	rile	pyre	---	oblige
/au/	---	town	---	cowl	hour	couch	gouge

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.* [-t□], 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). 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).

(19) 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

(19a) probably accounts for the absence of [au] before labial consonants in Table 2, *i.e.* [p], [b], [f], [v] and [m], whereas (19b) has much to do with the lack of [au] + [k] in the same table. The exceptions in (19a, b), in turn, can probably be attributed to the phonetic fact that /u:/, but not /i:/, shares articulatory features with labial and velar consonants.

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: section 4.3).

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

	/-sp/	/-st/	/-sk/	/-lp/	/-lt/	/-lk/
/ai/	---	heis	---	---	---	---
/au/	---	joust	---	---	---	---

	/-mp/	/-nt/	/-□k/	/-ps/	/-ts/	/-ks/	/-pt/	/-kt/
/ai/	---	pint	---	---	---	---	---	
/au/	---	fount	---	---	---	---	---	

In sum, [ai] can cooccur with a coda consonant more freely than [au] in English. This synchronic asymmetry between the two diphthongs seems to be essentially of the same type as the asymmetry we saw for Japanese in section 3.

5. CONCLUDING REMARKS

5.1. Summary

In this paper we have looked at several independent facts which suggest that [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. On the other hand, the asymmetry in 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 the history. We also saw a historical fact that [au] underwent vowel coalescence not only more productively than [ai] but also at an earlier stage in the language. Furthermore, a careful analysis of the phonological structure of loanwords in Japanese reveals at least three facts pertaining to the markedness of [au], all of which suggest that [au] is a rather unstable diphthong turning very easily into a monophthong. It was pointed out that [au], but not [ai], patterns with long vowels, which also tend to shorten in similar phonological contexts.

5.2. Remaining problems

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]. This question can be tackled from two different perspectives. First, one can ask if [au] is more marked than [ai] cross-linguistically. We saw that [au] is much less frequent and stable than [ai] in both English and Japanese, but we should ask if the same asymmetry is observed in other languages.

If cross-linguistic studies have shown that [au] tends to be more marked than [ai] in languages in general, we can then consider the nature of [ai]-[au] asymmetry from a second perspective by asking ourselves why that should be the case. I have hinted in passing that the relative markedness of [au] over [ai] may reflect a more general difference in markedness between diphthongs ending in [u], *e.g.* [iu], [eu], and those ending in [i], *e.g.* [ui], [oi]. This seems to be true at least as far as Japanese is concerned, but we should ask if the same is true of other languages. If this can be borne out, we may go one step further to suspect that the [ai]-[au] discrepancy in question may have to do with the markedness of the monophthong [u] over [i]. All these questions remain unanswered.

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NOTES

1. 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 diphthong and the values of [low] and [back] from the second element. See Kubozono (1999b) for the details of this featural analysis.

2. Historically, all the words in the input arguably come from CVCVCV forms *via* consonant deletion: *e.g.* /hayasi/ → /hayai/, /hayaku/ → /hayau/.

3. I thank Donna Erickson for drawing my attention to Stevens's work.

4. Long vowels also seem to shorten in loanwords when they appear before a schwa: *i.e.* [V□□] → [V□]. This will be equivalent to the shortening of [au] to [a] in (8b).

5. This does not mean that /aiN/ is accepted as a trimoraic syllable in Japanese. A careful analysis of the accentual behaviour of /aiN/ suggests that it actually consists of two syllables with a syllable boundary within [ai], *i.e.* /a/ + /iN/ (see Kubozono 1993, 1995, 1999a for details).

6. 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 2001).

7. It is not clear yet what triggers pre-nasal shortening of /auN/ as in (10a) and what blocks this same process in the words in (13). 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.

8. Kuwamoto (1998b) makes the same observation but fails to notice that /auN/ behaves differently from /aiN/.

9. 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 (17a)/(18a), whereas no such compensation occurs when they appear in the final position (17b)/(18b) (Kubozono, forthcoming).

10. 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 top.pu → [daN][to.pu] `by far the best'

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