Some Factors concerning Vowel Devoicing: Consecutive Vowel Devoicing and Morpheme/Word Boundary

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1 Introduction*

It is well-known that many factors influence vowel devoicing in Japanese. This report describes the results of an investigation into the influence of morphological/word boundary on devoicing by using acoustic analysis. Further, I will try to demonstrate how this influence affects consecutive devoicing.

2 General Procedure

Eleven native Japanese speakers, 9 female and 2 male, participated in this experiment. All subjects were born in Tokyo and its suburbs.

All test words were embedded in a natural short sentence and written in Japanese orthography. The sentence was presented to the subjects, one by one, in a randomized order display on a PC. Subjects were instructed to read the sentence at a speed most comfortable for them. Recordings were made in a quiet room with an MD or a DAT recorder. The data was analysed with a speech analysis program (created by Ono-sokki) and executed on a PC. The devoicing was judged by the absence of a periodical wave or voice bar on a sound spectrogram.

3 Phonetic Environment

Let us consider the influence of phonetic environment on devoicing. According to Han (1962), /u/ is more likely to be devoiced than /i/. If this is right, in light of the fact that Japanese /u/ is assumed to be a non-rounded vowel, her result should point toward some interesting association between the vowel and devoicing. However, no clear differences in the vowel quality in speech can be found.

Han and many researchers also argue that consonants have some effect on devoicing. As my previous study (Yoshida & Sagisaka 1990) and other similar studies have shown, some fricatives sometimes inhibit the devoicing of the neighboring vowel. The first experiment below intends to explore whether this phonetic environment really affects devoicing.

3.1 Experiment 1

In this experiment, the stimuli have the following formation at the beginning (C=consonant, V=vowel).

Chart 1

C1	V1	C2	V2
k	i	k	i
s	u	s	u
			a

Two consonants (k,s) before the vowel, two target vowels (i,u), two consonants (k,s) after the vowel, and three vowels (i,a,u) after the second consonant yielded a total of 24 sets of devoiceable environment. Thus, 12 sets of phonetic environments were constructed for each target vowel. I asked the subjects to pretend that these words were foreign place names. As the test words were longer than 4 mora, it was reasonable to suppose that the words were to be read in an antepenultimate or flat accent (typical long loan word accent in Japanese: see Akinaga 1993). In this manner, we could avoid locating the accent nucleus on devoicing mora. All speakers read the words with the above-mentioned accent. As a result, I would like to think that there is no accentuation influence on devoicing.

3.2 Results

Table 1

	/i/	/u/
Average Devoicing Rate	79.8%	77.7%

Table 2 ('V' denotes closed vowel, i.e. /i/ and /u/)

	/kVk/	/kVs/	/sVk/	/sVs/
Average Devoicing Rate	92.4%	90.9%	98.5%	27.3%

Table 1 shows that no significant differences in devoicing rate exists between /i/ and /u/[$F(1,11) < 0.11$ n.s.]. Next, Table 2 highlights that the vowel between fricatives (/s/) is more likely to be voiced than the vowel in the other environments. This result is consistent with Tsuchida's findings. Further, we can see that the vowel between /s/ and /k/ is the most easily devoiced vowel.

4 Effects of Word Boundary

As in many languages, some types of words in Japanese are combined to form a compound. Especially, Sino-Japanese (*kango*) are extremely rich in their compounding possibilities (Itô and Mester 1993). For example, /zyusi/ 'resin', /shokuhin/ 'food' and /kakoo/ 'processing' can be used as a simple word. And /zyusi#kakoo/ 'resinate' and /kakoo#shokuhin/ 'processed food' are examples of compounds consisting of these words. You should note

that these compounds have only one accent locating at the first mora of the second part (zyushika'koo/kakoosho'kuhin). This accentuation makes the word a compound, not a word sequence (Kubozono 1993).

Vance (1992), Tsuchida (1997) and some other researchers have pointed out that the vowel is less to be devoiced at a word boundary. The next experiment shows the effect of the Sino-Japanese compound boundary on the vowel devoicing before it.

4.1 Experiment 2

Eleven environments have been prepared for this experiment (see Table 3). All words which contain these environments consist of two parts (see data set 1). Each part has two kanji characters. As a consequence, each compound word has four kanji characters as a whole. All words have voiceless consonants (/s,k,t/) at the beginning of the second part. And the last mora of the first part consists of a voiceless consonant and vowel /i,u/. These vowels before boundaries can be devoiced. The subjects for this experiment were 7 female and 2 male.

For a comparison, I wish to examine another set of words with a similar devoiceable environment (see data set 2). These 11 words also have two parts. The first part is a Sino-Japanese word, like the examples appeared in data set 1. For example, /kagaku/ in 1a and 9b is the same word. But all of the second parts of the set in data set 2 are morphemes (suffixes). These morphemes are very productive, but never appear solely. Consequently, in these words, the target vowel is located before morpheme boundary.

4.2 Results

Table 3 (devoicing rate)

Environment	Compound boundary	Morpheme boundary
ku#/-sa	100%	100%
ku#/-se	100%	100%
ku#/-te	54.5%	90.0%
ku#/-to	100%	100%
ki#/-k	100%	100%
ku#/-k	80.0%	100%
ti#/-s	54.5%	100%
tu#/-s	100%	100%
tu#/-t	90.9%	100%
tu#/-k	100%	100%
si#/-k	72.7%	100%
Average	86.7%	99.2%

Table 3 shows clear differences between compound boundaries and morpheme boundaries in effecting on devoicing before them. Except only one utterance in an environment (/kute/), the vowels before morpheme boundaries are devoiced. But, in nearly half of these environments (5/11), the vowels before compound boundaries are voiced. For instance, I mentioned above that the vowel in the environment /sVk/ is very devoiceable (see Table 2).

For our subjects, devoicing rate of /i/ in /s̲ika/ ‘deer' and /as̲ika/ ‘sea lion' is 100%. As in Table 3, the rate of the vowel before morpheme boundary is also 100%. On the contrary, in the same table, the devoicing rate of the vowel differs only in this type of boundary after it is 72.7%. It follows from this finding that the affecting of boundary is limited to the boundary in a compound. This result have a correlation with the contraction in Sino-Japanese such as /gaku/+/kai/-->/gakkai/ ‘learned society'. The contraction can only happen at the end of a stem, not a word (see McCawley (1968), Itô & Mester (1993)). Note that the environment of this contraction is similar to that of vowel devoicing. Thus, the result in Table 3 suggests that there is a same limitation on both devoicing and contraction.

As noted above, the vowel before compound boundary is voiced in five out of eleven words. Is there any difference between these five words and the rest? We got different results in a similar phonetic environment in Table 3. In this example,/ti#s/ and /tu#s/ have a similar environment (different only in vowel quality). But the devoicing rate is 100% and 54.5%, respectively. In other examples, it is difficult to find the exact relationship between the devoicing rate and the phonetic environment.

We can, however, find an interesting relation between the mora length of each part of the compound and the devoicing rate.

Table 4

	Length in mora		
	First part	Second part	Devoicing rate
Group A	2	4	54.5%
	4	3	54.5%
	2	3	72.7%
	4	3	80.0%
	4	3	90.9%
	3	4	100.0%
Group B	3	3	100.0%
	3	3	100.0%
	3	3	100.0%
	4	4	100.0%
	4	4	100.0%

The compounds belonging to Group A have a difference between the first part length and the second part length. In this group, 5 out of 6 vowels in the compounds are voiced. In contrast, all the compounds of Group B which have the same length in both parts are devoiced. The result suggests that there is some relation between the phonological structure of Sino-Japanese compound and devoicing. Ito & Mester (1993) have stated, "Prosodically, there is a size limit on Sino-Japanese stems." This could be a phenomenon related to the result in Table 4. But further research is needed.

5 Consecutive Devoicing Environment

According to the *NHK accent dictionary* (1998), when two vowels are in successive devoicing position, one of the two tends to be voiced. When three or more consecutive devoicing environments are made, the vowel in the medial position is to be voiced. Maekawa (1989) discusses the pattern of consecutive devoicing. In his example, although the word /shukufuku/ ‘blessing' contains four successive devoiceable environments (including the vowel at word final position), only two devoicing patterns are assumed to be dominant in natural speech. These patterns are /shukufuku/and /shukufuku/, respectively. It appears strange that the second and the fourth vowels are devoiced (/shukufuku/). Anyway, investigations have found that devoicing tends to be avoided in the consecutive devoicing environment. But it is not clear which vowel devoicing should be avoided. In the studies above, the position of the vowel in a word seems to be crucial. Vance (1992) says, "The vowel in the third syllable to be devoiced rather than the vowel in the second syllable."

In Yoshida (1996), I showed the devoicing pattern in consecutive environment (see Table 5). Each word has two consecutive devoiceable environments in the second and the third mora[note 1].

Table 5 (Yoshida 1996 revised)

Word	2nd V	3rd V	VC
/asi#huki/ ‘bath mat'	0.0%	100.0%	0.0%
/taki-tuke/ ‘kindling'	0.0%	100.0%	0.0%
/uki#kusa/ ‘duckweed'	7.1%	92.9%	7.1%
/tokusi-ka/ ‘philanthropist'	14.3%	100.0%	0.0%

In the words in the first three rows, (/asi#huki/[note 2], /taki-tuke/, /uki#kusa/), almost all first vowels in the successive devoicing environment are voiced. However, the second vowels in the same environment are devoiced at a very high rate. Therefore, consecutive devoicing is really avoided in most of these words. Because there is a boundary between these morae, this avoidance may be due to the following boundary (note that its type is irrelevant to this phenomenon). But in /tokusi-ka/, the vowel before boundary is devoiced in all subjects. Thus, it is doubtful that the boundary really affects the voicing of the vowel before it.

The next possible implication of this result is the effect of the position in a word. In the examples in Table 5, the vowels in the third mora are more devoiceable than those in the second mora. This result is consistent with Vance's view. In the next experiment, I will show the effect of devoiceable vowel position.

5.1 Experiment 3

Two devoiceable environments, /kis/ and /sit/, are the target of this experiment. The vowels in these two environments are so devoiceable that their devoicing rate reaches nearly 100%. For example, /kisi-be/ ‘shore' and /kisaku/ ‘friendly' have /kis/ environment at the beginning of each word. In these words, only one out of 22 utterances is voiced. The rate of devoicing is 95.5%. Similar tendency can be found for /sit/. Devoicing rate of the first vowel in /sita/ (these are homonyms : one is the past form of verb /suru/ ‘do' and the other means 'tongue') is 100%. I united /kis/ and /sit/ to make a consecutive devoicing environment /kisit/ and

selected four words (/kisitu- (gata)/ 'temper (type)', /yukisitu/ 'quality of snow', /tekisitu/ 'enemy error', /rekisi-teki/ 'historical') containing this environment. The devoicing rate of each vowel is shown in Table 6.

Table 6

Word	1st V	2nd V	3rd V	VC
/kisitu- (gata)/	27.3%	100.0%	-----	0%
/yukisitu/	-----	0.0%	100.0%	0%
/tekisitu/	-----	18.2%	100.0%	0%
/rekisi-teki/	-----	27.3%	90.9%	0%

A glance at Table 6 reveals that the devoicing rate of the vowel /i/ in /kis/ is extremely low. As mentioned above, the rate of this vowel in non-consecutive environment is nearly 100%. It is obvious that this contrastive result is due to the consecutive environment. Contrary to this, nearly all the vowels /i/ in /sit/ are devoiced. It should be noted that its position in a word is irrelevant to the devoicing rate. From this data, the crucial factor seems to be an order in the devoiceable environment sequence rather than the position in a word. That is to say, the vowel in the second mora of the sequence is more devoiceable.

But we encounter difficulties when we see following example having a similar environment.

Table 7

Word	1st V	2nd V	VC
/tukusinbo/ (***)'horsetail'	100%	13.6%	0%
/katiku-ka/ 'to be domestic'	81.8%	63.6%	0%
/tVk/	100% (average of 3 words)		
/kVs/	100% (average of 4 words)		
/kVk/	86.4% (average of 2 words)		

The words in the first two rows have the consecutive devoiceable environment similar to the above. If we can ignore the difference in the vowels, the environment can be divided into three types of environments (/tVk/,/kVs/,/kVk/). As shown in the table, if these three environments appear solely, they show a high devoicing rate. Table 7 reveals results which are contrastive to the ones in Table 6. It is the vowel in the first mora of the consecutive environment that shows a relatively high devoicing rate.

Here is another possible explanation for these contrastive results. It is well known that plosive /t/ appears as an affricate before /i/ and /u/ in Japanese. In general, affricates can be considered as a stop followed by a fricative. If this view is right, when affricates occur before vowels, they may behave like fricatives. We have seen in Table 2 that the vowel in /sVk/ is the most devoiceable. If we can assume that fricative (including affricate)-vowel-plosive sequence is the most devoiceable environment, all the vowels with a relatively high devoicing rate in the example above belong to this environment. It follows

from this that the crucial factor in consecutive devoicing might be phonetic environment rather than boundary or other factors. However, it is necessary to conduct more extensive experiment.

6 Summary and Conclusion

In this report, by using the acoustic analysis, I have examined an important aspect of Japanese vowel devoicing. I have demonstrated two factors.

1. A boundary in a Sino-Japanese compound occasionally prohibits the vowel before it from devoicing.
2. Consecutive devoicing tends to be avoided. It is phonetic environment which vowel in this consecutive environment should be devoiced. It is the phonetic environment which determines the vowel to be devoiced in a consecutive environment. The effect of the boundary and the position in the word seems to be weak.

7 NOTES

* To simplify description, the following abbreviations are used in this report.

/ # /	word boundary
/ - /	morpheme boundary
/ ’ /	accent nucleus
VC	voiced

1 Although subjects in this experiment were not born in Tokyo, all the words using in this experiment are belonging to standard Japanese.

2 A voiced sound follows the last vowel of /asi#fuki/, as a result three successive devoicing doesn’t occur in this word.

3 With a dimunitive suffix /-inbo/.

Data set 1 (underlines denote target vowels)

1a: /yuukɨ#kagaku/ ‘organic chemistry'
2a: /sinzokɯ#kaigi/ ‘family council'
3a: /zyusɨ#kakoo/ ‘resinate'
4a: /muketɯ#kakumee/ ‘bloodless revolution'
5a: /kagakɯ#sayoo/ ‘chemical action'
6a: /kagakɯ#seNi/ ‘synthetic fiber'
7a: /zitɨ#seesiN/ ‘self-government'+'attitude'
8a: /dokuritɯ#sensoo/ ‘war of independence'
9a: /taisyokɯ#teate/ ‘retirement allowance'
10a: /kenryokɯ#toosoo/ ‘power struggle'
11a: /dokuritɯ#toosi/ ‘investment in self-supporting accounting system'

Data set 2 (underlines denote target vowels)

1b: /kagekɨ-ka/ ‘to be extreme'
2b: /bunkyokɯ-ka/ 'polarization'
3b: /hanasɨ-ka/ ‘comic storyteller, professional *rakugo* player'
4b: /hooritɯ-ka/ ‘lawyer'
5b: /gaikokɯ-san/ ‘imported'
6b: /sekkyokɯ-see/ ‘positiveness, enterprise'
7b: /zennitɨ-see/ ‘full-time schooling system'
8b: /kootetɯ-see/ ‘made of steel'
9b: /kagakɯ-teki/ ‘scientific'
10b: /chookokɯ-too/ ‘chisel'
11b: /hakunetɯ-too/ ‘incandescent lamp'

8 References

Akinaga, K. (1993) *Meikai Nihongo Akusento Ziten.* Sanseido.

Han, M.S. (1962) *Japanese phonology*. Kenkyuusha.

Ito, J. and A.Mester (1993) 'Stem and word in Sino-Japanese.' Proceedings of Dokkyo forum 1993

Kubozono, H. (1993) *The organization of Japanese prosody*. Kurosio publishers.

McCawley, J.D. (1968) *The phonological component of a grammar of Japanese*. Mouton.

Maekawa, K. (1989) 'Boin-no museika (Devoicing of vowels).' in *Kouza nihongo to nihongokyooiku.* Meiji shoin.

Tsuchida, A. (1997) 'Phonetics and phonology of Japanese vowel devoicing.' Doctoral dissertation, Cornell University.

Vance, T. (1992) 'Lexical phonology and Japanese vowel devoicing.' in *The joy of grammar ; Brentari et al. (eds)* John Benjamins publishing company.

Yoshida, N. and Y.Sagisaka (1990) 'Boinmuseika-no youin bunseki (Factor analysis of vowel devoicing).' ATR technical report TR-I-0159

Yoshida, N. (1996) 'Museika-ni eikyou-wo ataeru youin-ni tuite (Factors affcting on devoicing).' Proceedings of the 10th general meeting of the PSJ (Phonetic society of Japan).

Yoshida, N. (1997) 'Boin-no musika-ni eikyou-wo ataeru youin (Factors affecting on vowel devoicing).' Proceedings of the meeting of Kokugogakkai (The society of Japanese linguistics).

Nihon hosoo kyoukai <NHK> (1998) *Nihongo Hatuon Akusento Ziten.* Nihon Hosoo Kyoukai Shuppan.