Ann.Bull.RILP(1984)No.18, 83-90

VOWEL DURATION IN /hū ku/ AND /hukū / IN JAPANESE

Fukuko Kuriyagawa and Masayuki Sawashima

Introduction

It is known that Japanese word accent, which is typically represented by changes in the fundamental frequency of voice, plays an important role for differentiating word meaning. It is also said that word accent was a certain effect in the devoicing of vowels in Japanese. M. S. Han has stated that

> "The phenomenon of unvoicing of vowels has a close relationship with pitch-accent. When /i/ or /u/ occurs in a 'virtual' accented syllable, unvoicing is not common, though otherwise they are in the environment typical of the unvoicing phenomenon."[1)]

The goal of the present study was both to observe the unvoicing of vowels and to measure the duration of vowels with the minimal pair of the two-mora words /hū ku/("blow" in the Tokyo accent) and /hukū /("wipe" in the Tokyo accent), which are differentiated only by the word accent. For /hū ku/ the fundamental frequency pattern for the sequence of the first and the second moras is high to low, while for /hukū /, in contrast, the pattern can be characterized as low to high.

Procedure and Method

Three pairs of sentences containing the two test words of /huku/ were designed for comparison. These sentences were as follows.

test words: /hū ku/ (blow), /hukū / (wipe)+

+ In the case where /h/ precedes /u/ in Japanese, it changes to the sound transcribed as [ɸ] in narrow phonetic transcription but is usually transcribed as "f" in the Hepburn Romaji transcription used in Japan. The three kinds of transcription mentioned above differ as follows.

1. "fuku" in Hepburn Romaji transcription
2. [ɸuku] in phonetic transcriotion
3. /huku/ in Phonemic transcription

According to the Dictionary of Japanese Pronunciation and Accent[2)], two types of accent are found for /huku/(blow), that is to say, /hū ku/ and /hukū /. Both subjects in the present study pronounced /huku/ (blow) in the former way.

sentence 1:/huku/ "He blows." and "He wipes."

sentence 2:/huewohuku/ "He blows a pipe."
"He wipes a pipe."

sentence 3:/huewohukuka#awawohukanaika/
"Whether he blows a pipe or does not blow bubbles."
"Whether he wipes a pipe or does not wipe bubbles."

Sentence 1 is a kind of one-word sentence and serves as a reference for the other two test sentences. Sentence 2 and sentence 3 were made by adding different words or word groups to the head or the end of sentence 1. Two subjects speaking Tokyo dialect, one male and the other female, read these sentences at a normal tempo for their speech more than ten times each. The recording was performed in a anechoic recording studio at the University of Tokyo. The speech sounds were analyzed by means of a LPC analysis program 3), and the results were then calculated and examined with the SPSS program on the VAX-11/780 system. In the present study, the duration of a vowel was defined as the time period when a periodic (or quasi-periodic) vibration for the vowel was observable on the speech wave. The measurement unit for duration was 0.1 msec. The relative duration of each segment in the word was calculated for each case.

Results

1. Unvoicing of the vowel

The wave forms of 96 sentences for subject M.S. and 92 sentences for subject F.K. were examined for the minimal pairs of /huku/ in three types of sentences. The number of samples treated here is given in Table 1.

Table 1 Number of samples for each subject.

Subject	Word	Sentence	N	Total
1)M.S.	hu̥ ku	1	23	
		2	13	45
		3	9	
	huku̥	1	25	
		2	14	51
		3	12	
2)F.K.	hu̥ ku	1	19	
		2	13	44
		3	12	
	huku̥	1	21	
		2	15	48
		3	12	

Table 2 showes the incidences of voiced or unvoiced vowels in relation to the two words by both M.S. and F.K., respectively. As for the results for subject M.S.,the vowel of the first mora,u_1, was unvoiced and the vowel of the second mora, u_2, was voiced in every case despite the differences in accent between the two words. Concerning /hu͡ku/ produced by subject F.K., the vowel u_1 was pronounced unvoiced in 93% (41 cases) of the total(44 cases). As for vowel u_2 in these 41 cases, 30 cases(68% of 44 cases) were voiced but 11 cases (25% of 44 cases) were unvoiced. In relation to the rest of the cases which contained a voiced u_1(3 cases,7% of 44 cases) in /hu͡ku/, one of them (2% of 44 cases) was unvoiced in the final vowel u_2, but in the other two cases(5% of 44 cases) u2 was voiced. On the whole the final vowel u2 was unvoiced in 12 cases (27% of 44 cases) for /hu͡ku/.

As for /huku͡/ produced by subject F.K.,however, the vowel u_1 was unvoiced and the vowel u_2 was voiced in every case as in subject M.S.

Table 2 The occurrence of unvoicing or voicing in /u/ of the first(u_1) and the second mora(u_2).

1)Subject:M.S.

	u_1			u_2		
Word	V/UV	N	%	V/UV	N	%
hu͡ku	UV	45	100	V	45	100
huku͡	UV	51	100	V	51	100

2)Subject:F.K.

	u_1			u_2					
Word	V/UV	N	%	V/UV	N	%	Sentence	N	%
hu͡ku	V	3	7	V	2	5	Sentence 1		5
				UV	1	2	Sentence 1		2
	UV	41	93	V	30	68	Sentence 1	14	32
							Sentence 2	13	30
							Sentence 3	3	7
				UV	11	25	Sentence 1	2	5
							Sentence 3	9	20
huku͡	UV	48	100	V	48	100			

V:Voiced, UV:Unvoiced, N:Number of occurrences

2. Fundamental frequency

The difference in the fundamental frequency contour for u_2 between /hū ku/ and /hukū/ is conspicious(Fig.4). The u_2 of /hū ku/is characterized by a fall in the fundamental frequency throughout the vowel segment. u_2 of /hukū/,in contrast, stays flat or falls slightly for the duration of the vowel, or even rises a bit towards the end and the falls. This feature has been studied and discussed in detail by M.Sugito[4,5].

3. Duration

Here we report only on the duration of vowel u_2, because u_1 was almost always unvoiced. Table 3 give mean values of the measurement. The data are also displayed in Fig. 2. It is also noted that the duration of u_2 in sentence 3 is shorter than that in sentence 1 and sentence 2.

Table 3 Comparison of the duration of final /u/(u_2) between /hū ku/ and /hukū/ for three pairs of sentences.

1) Subject:M.S.

Sentence	Word	N	Duration (msec)	Relative duration(%)	Duration of word (msec)
1	hū ku	23	155.7*	42.9***	362.9
1	hukū	25	184.2	45.1	408.4
2	hū ku	13	137.0*	40.2*	340.8
2	hukū	14	188.4	45.0	418.7
3	hū ku	9	75.3*	31.6*	238.3
3	hukū	12	106.4	37.0	287.6
Total	hū ku	45	134.2*	39.8*	337.2
Total	hukū	51	167.1	43.2	386.8

2) Subject:F.K.

Sentence	Word	N	Duration (msec)	Relative duration(%)	Duration of word (msec)
1	hū ku	16	127.9**	31.6*	404.4
1	hukū	21	147.0	40.5	363.0
2	hū ku	13	106.2*	29.7*	357.6
2	hukū	15	151.0	40.8	370.1
3	hū ku	3	74.1*	33.1?	223.9
3	hukū	12	91.1	32.2	282.9
Total	hū ku	32	114.0*	31.0*	367.7
Total	hukū	48	134.2	38.5	348.6

Significance levels are as follows:

(*) $p \leq 0.005$, (**) $p < 0.01$, (***) $p < 0.02$, (?) Inadequate to test+

+ As the vowel u_2 of /hū ku/ was often unvoiced in the case of sentence 3 by subject F.K., the number of cases is not sufficient to compare the mean values of the duration between /hū ku/ and /hukū/.

Discussion

In subject M.S., the first vowel, /u/ following /h/, was always unvoiced. In subject F.K., unvoicing also occurred far more frequently for the first /u/ than for the second one. The results appear to be in agreement with the assumptions by M. S. Han that

> "In the sequence in which the voiceless consonants are stops and non-stops (that is to say fricatives and africatives) the vowel preceded by non-stops are more readily unvoiced while the vowels preceded by stops tend to remain voiced."6,7)

In subject F.K., the rate of occurrence of unvoicing for the first /u/ was 93% for /hu̥ku/, while it was 100% for /huku̥/. Also, the rate of occurrence of unvoicing for the second /u/ was 27% for /hu̥ku/, while it was 0% for /huku̥/. This result is in agreement with the assumption by M. S. Han that

> "When /i/ or /u/ occurs in a 'virtual' accented syllable, unvoicing is not common, though otherwise they are in the envirament typical of the unvoicing phenomenon."1,8)

But it does not apply to the result by M.S., where all of the second /u/ was voiced in both accent types. Fundamental frequency pattern for u_2 appeared to give a characteristic difference between the two accent types. It is interisting to note that the duration of u_2 for /hu̥ku/ was constantly shorter than that for /huku̥/. It is considered that the Japanese word accent is characterized not only by the fundamental frequency, but also by the duration of the vowel. A shorter duration of u_2 for sentencee 3 compared with sentences 1 and 2 may be explained by the difference in the context. In sentences land 2, u_2 was in the position of sentence final, while it was not so in the sentence 3. Further study is needed on this problem.

Summary

The duration of segments in two pairs of Japanese words consisting of the same sequence of phonemes, /hu̥ku/ and /huku̥/, was examined in wave forms in terms of both the occurrence of unvoicing and the duration of vowels.

1) The unvoicing of vowels occurs mostly in the case where the vowel follows the voiceless fricative consonant, regardless of which mora the accent put on.
2) The difference between the duration of the final vowel of /hu̥ku/ and that of /huku̥/ was significant with the latter

being longer.

3) It is assumed that the word accent represented by the changes in the fundamental frequency affects on the duration of the final vowel in the sequence /huku/ when the two words /hū ku/ and /hukū / are differentiated from one another.

Acknowledgement

We wish to express our appreciation to Mr. Hiroshi Imagawa for his advice in utilizing the LPC analysis program.

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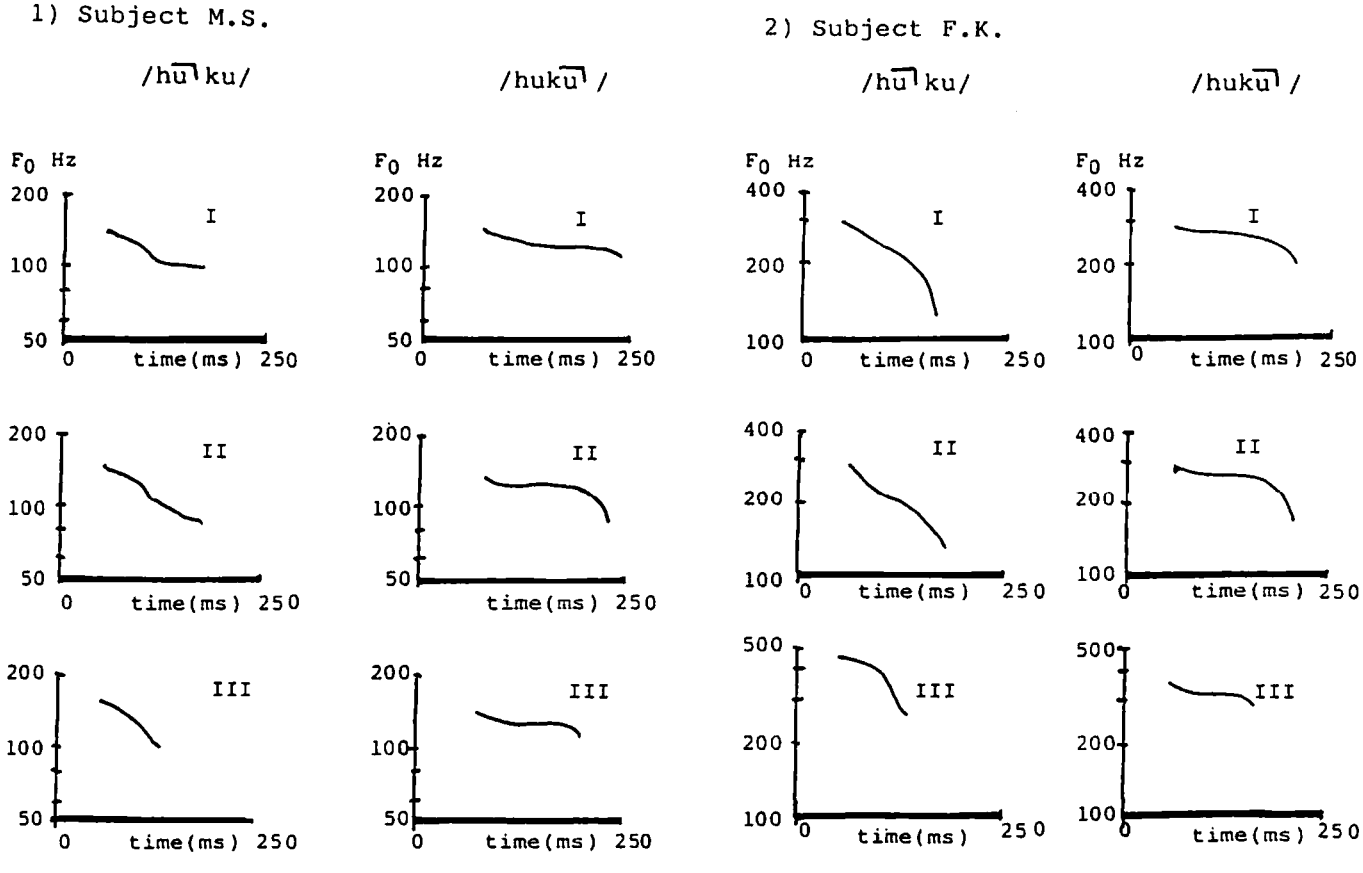
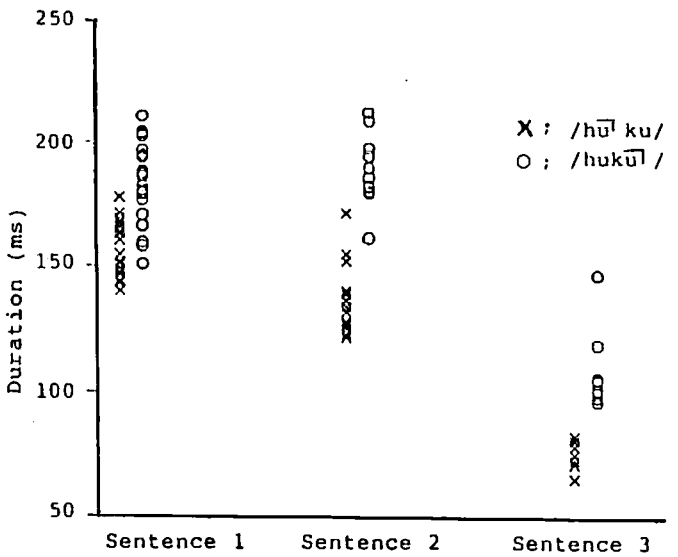


Fig.1 The fundamental frequency contour for the final vowel /u/ in /hūku/ and /hukū/ for sentences 1,2 and 3.

1) Subject M.S.



2) Subject F.K.

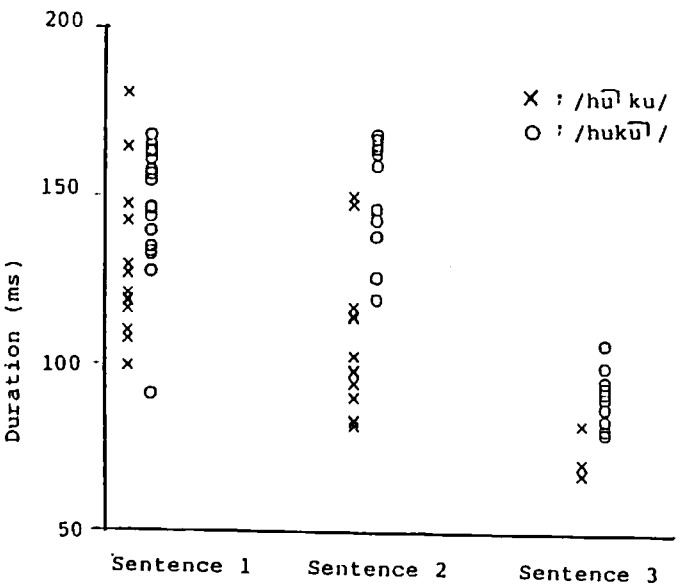


Fig.2 Duration of the final vowel /u/
for Sentences 1, 2 and 3.