EFFECT OF ACCENT AND SEGMENTAL CONTEXTS ON THE REALIZATION OF VOWEL DEVOICING IN JAPANESE

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ABSTRACT

Realization of vowel devoicing in Japanese was examined acoustically by varying accentual and segmental factors on nonsense words systematically. Effect of accent was found to be quite small, affecting only those vowels which occurred before [ɕ, ç, f]. There was a tendency for a vowel to resist devoicing when it was adjacent to [ç] and [f]. The phonetics and phonology of vowel devoicing in Japanese is discussed.

INTRODUCTION

There has been growing interest in the phenomenon of vowel devoicing in recent phonetic literature. These studies indicate that the phonetic conditions in which vowels are devoiced across several languages are extremely similar.

Vowel devoicing has hitherto been most extensively studied for Japanese. A standard description is that the high vowels /i/ and /u/ are devoiced between the two voiceless consonants, or between a voiceless consonant and a pause. It is known that devoicing is influenced by both segmental and accentual factors. However, it was not until recently that the relationship between the two factors was considered [1, 2]. While these two studies have concentrated on counting the frequency/rates of devoiced vowels in a dictionary and large database respectively, the present study focuses on an acoustic analysis, using a well-controlled material in which segmental and accentual factors are varied systematically. Potential spectral, durational, and intensity changes across these two variants have not been explored previously.

MATERIAL AND ANALYSIS

The corpus consisted of nonsense words having three CV syllables, where the segments in the first CVC were varied systematically. All possible combinations of devoiced vowels were included (cf. Table 1). The nonsense words such as *pipaka, pitaka, pikaka,* were embedded in a carrier sentence "Korewa ___ desu " (this is ___).

The entire corpus consisted of 110 words and it was read twice by a female speaker of Standard Japanese for each accent category at a comfortable speaking rate. Total of 440 samples were obtained. All speech material was digitized at 20kHz sampling rates. Duration and intensity (dB) were measured using the spectrograph and energy calculation commands of the CSL software package installed on a PC. Intensity was measured at a point approximately one third from the end of the frication phase.

RESULTS

Realization of devoicing

Results of the realization of vowel devoicing in different segmental contexts are shown in Table 1 with accent information. It is shown that there were three types of realizations: (1) those which were devoiced regardless of accent category, (2) those which were not devoiced, and (3) those which were not devoiced when accented. The vowels in the categories (2) and (3) all belong to the syllables which were followed by the postvocalic [ɕ, ç, f]. Those vowels which were not devoiced regardless of accent occurred more often with [ç] or [f] as the adjacent consonant.

Acoustic manifestation

In the present material, the vowel in question appeared in the initial syllable of CVCVCV, which was embedded in a carrier sentence. When the vowel was devoiced after a stop consonant, its presence was usually detectable in the much longer duration of aspiration (or frication noise), and the difference in quality (/i/ or /u/) was shown as different spectral patterns (cf. Figure 1). Syllables such as /pi, pu, ki, ku/ all had this pattern with slight reduction in duration and intensity when unaccented. Differences in quality between [ɕi̥] and [ɕu̥] with devoiced vowels, is more difficult to identify spectrographically.

*Table 1. Effect of accent and segmental contexts on the realization of vowel devoicing. *=was devoiced, X=was not devoiced, A=was not devoiced when accented. Two tokens for each syllable.*

	post-vocalic C									
syllable	p	t	k	tɕ	ts	s	ɕ	h	ç	f
pi	*	*	*	*	*	*	*	*	A	A
pu	*	*	*	*	*	*	A	*	A	X
tɕi	*	*	*	*	*	*	X	*	X	X
tsu	*	*	*	*	*	*	A/*	*	X	X
ki	*	*	*	*	*	*	A	*	A	X
ku	*	*	*	*	*	*	A	*	A	A
su	*	*	*	*	*	*	A	*	A	A
ɕi	*	*	*	*	*	*	A	*	X	X
çi	*	*	*	*	*	*	A	*	A	X
ɕu	*	*	*	*	*	*	A	*	X	A
fu	*	*	*	*	*	*	A/*	*	X	X

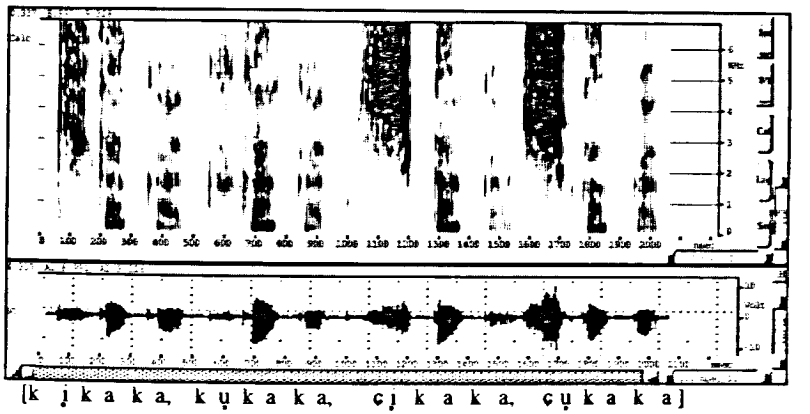

Figure 1. Sample spectrogram showing /kikaka, kukaka, ɕikaka, ɕukaka/ where /i/ and /u/ are devoiced.

Figure 2 displays sample tokens for [ki̥kaka, ku̥kaka, ɕi̥kaka, ɕu̥kaka].

The frication phase in accented syllables always had longer duration and the difference was found to be significant. Figure 2 presents the duration of frication phase for each syllable type except for [ç] since the recordings for this sound were unfortunately of poor quality.

As for intensity, the original material did not render reliable measurements of intensity partly because the recordings was divided into two sessions with a pause, partly because the speaker decreased overall intensity in the second session, and partly because the distance from the microphone was not fixed. These conditions made it difficult to do meaningful intensity measurements since the list was randomized. Therefore, the same speaker was called for an additional recording for some selected materials, this time using a headset microphone (cf. Figure 3). Like duration, the frication phase in accented syllables always had higher intensity, though the difference was not found to be significant by t-test for the pairs [pip, pits, ɕik, ɕitɕ].

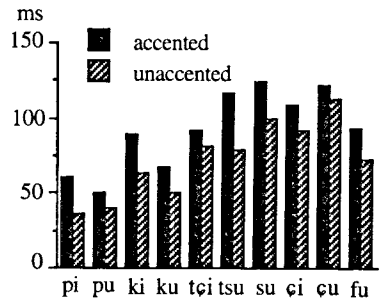

Figure 2. Duration of frication phase for each syllable type with or without accent.

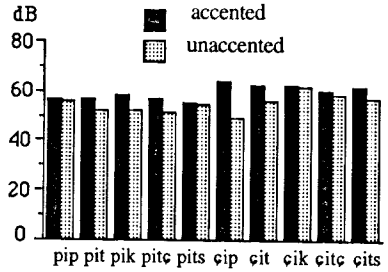

Figure 3. Comparisons of intensity of the frication phases of [pi] and [ɕi] before stops and affricates with or without accent.

DISCUSSION

Influence of accent

The influence of accent in the realization of vowel devoicing in Japanese has been known for a long time (cf. Sakurai [3] for a detailed description). By and large, it has been described that a potentially devoiceable vowel tends to resist devoicing once it is accented. Influence of accent, however, can appear in a different way by shifting accent to either the preceding or the following vowel. Many works using word in isolation form agree that accent indeed has a strong influence in preventing devoicing (cf. [2] for reference). However, recent works using longer words [4] and sentence database [2] found no overriding influence of accent in preventing devoicing. However, due to the restricted and uncontrolled curpus, these studies did not reveal much clearity as to the relationship between accentuation and segmental contexts.

In the present material of controlled corpus, the influence of accent on vowels in different segmental contexts appeared very regularly. Effect of accent in preventing devoicing was found only for those which were followed by [ɕ, ç, f]. The phenomenon appears partly phonological and partly phonetic because all these consonants are the allophonic variants before /i/ and /u/ (see discussion in next session), and because the three consonants do not behave exactly the same.

Influence of segmental context

The influence of prevocalic and postvocalic consonants has been discussed much in the literature and it has been indicated that there is a division between stops and fricatives. The division into stops and fricatives is also supported from physiological studies of glottal opening [8, 9].

Most studies agree that the phonetic nature of the postvocalic consonant is the most decisive factor in determining vowel devoicing, claiming that devoicing rate is higher when a vowel is followed by a stop than a fricative [5, 6]. The results of the present work agree with those of the previous studies in this respect except that the difference among fricatives became clearer in the present study. [s] and [h] behave besically the same as stops and affricates as postvocalic consonant.

The influence of prevocalic consonant is implicit in Kawakami's division of devoiced vowels in Japanese into two types: he says when [ki, pi, ku, pu, ɕu, tɕu] occur before a voiceless consonant, they will have devoiced vowels. On the other hand syllables [ɕi, tɕi, çi, su, tsu, fu] before a voiceless consonant usually do not even possess a devoiced vowel [7]. It is notable that the former group has, except for [(t)ɕu], stop consonants while the latter has fricatives.

The results of the present investigation indicate, however, that it is not adequate to consider the influence of adjacent segment in terms of segment alone. Instead, the nature of entire syllable should be considered. In the present study, those vowels which either did not get devoiced at all or affected by accent all occurred when they were followed by [ɕ, ç, f]. It should be remembered that [ɕ, ç, f] are the allophonic variants of /s/ and /h/ in Japanese: [ɕ] for /s/ before /i/, and [ç] and [f] for /h/ before /i/ and /u/ respectively. Furthermore, in the present material, these syllables were followed by [k], making the vowels in these syllables potentially devoiceable. In other words, in these words including [ɕ, ç, f], there were two succesive high vowels in a devoiceable environment. In only one word, namely in [ɕiɕika], both high vowels were devoiced regardless of accent. In all other words of this category, the first high vowel was either not devoiced at all or was affected by accent. It is interesting to note Kondo's results which report that devoicing of two successive syllables are avoided [4].

One interesting observation in this line of explanation, is that [tɕ] and [ts] do not behave similarly to [ɕ, ç, f] even though they too are the allophones (of /t/) before /i/ and /u/.

It may be at this point that the differentce between stop and fricative plays a role. In the acoustic signal, when a vowel is integrated in the frication phase or deleted all together, what is left is a frication phase. When a stop or affricate follows, there will be an occlusion after this phase, while if it were a fricative, another frication follows immediately. In the present material, except for [ɕiɕika], where both [i]s were devoiced, no two sequence of frication phases were observed when the first syllable was accented.

With few exceptions [10], the phenomenon of vowel devoicing has been discussed solely in terms of phonetics. However, the foregoing discussion indicates that the role played by phonology is considerable in the realization of vowel devoicing in Japanese. The problem we are concerned with is not the nature of prevocalic or postvocalic consonant per se. Rather, it is the question of which syllable including the vowel preceeds or follows, and how these syllables are structured within the enitre phonological system, where the allophonic variants of some consonants are typically found before high vowels.

ACKNOWLEDGEMENT

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