TEMPORAL ADJUSTMENT OF DEVOICED MORAE IN JAPANESE

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ABSTRACT

The effect of voiced and devoiced high vowels on moraic duration in Japanese were measured. Results showed that devoiced morae were significantly shorter than /CV/ morae. However, shorter durations of devoiced morae appeared to be adjusted at the word level, rather than within a mora. The apparent lengthening of moraic consonants was actually caused by the underlying devoiced vowel in the same mora.

INTRODUCTION

Standard Japanese is often cited as a Tmora-timed languageU. However, the theory of TmoraU as the basic unit of Japanese is disputable: the only convincing theoretical support is based on accentuation: lexical accent location is based on the moraic unit, not the syllabic unit.

It has traditionally thought that each mora in Japanese has a similar duration. In reality, many studies have agreed that the duration of morae actually differ, but there is a strong tendency for Japanese to try to equalise the duration of morae. (Hoequist Jr., 1983 [3], Sato, 1993 [6], etc.). Campbell and Sagisaka (1991) [2] did not find equal duration of morae in raw durations, but normalising segmental durations using z-score, they found mora-based segmental elasticity and duration compensation within CV sequences (moraic units) rather than V-C sequences (non-moraic units).

Some studies have questioned the phonetic reality of morae, notably Beckman (1982) [1]. Beckman measured the duration of segments and morae in various segmental combinations, but the mora did not appear to have phonetic reality.

Port et al (1987) [5] demonstrated that the duration of each mora was not necessarily equal, but the number of morae in a word determined the duration of words.

Most studies on temporal features in Japanese have not examined cases of devoiced morae. In Standard Japanese, high vowels /i,u/ are devoiced between voiceless consonants, or between a voiceless consonant and a pause. When a vowel is devoiced, the preceding consonant becomes moraic, constituting a mora on its own without a vowel. Beckman (1982) [1] showed that moraic consonants were not consistently longer than the non-moraic consonants.

Port et al (1987) [5] did not measure the duration of devoiced morae, but measured the duration of whole words with a devoiced mora and found that even when there was a devoiced vowel in a word, its duration was still adjusted and the word duration was fairly constant dependent on the number of morae in the word.

If morae with a devoiced vowel are considerably shorter than CV morae, does durational adjustment still operate at the word level? The results from the above studies have shown some sort of durational adjustment of segments based on mora, but are devoiced morae simply durational exceptions? If there are more than one devoiced mora in a word, does the word duration still maintain the target duration based on the number of morae in a word?.

This paper will investigate two levels of durational adjustments with particular relation to devoiced morae and words with devoiced morae. Principally, the following points will be examined: (1) the duration of devoiced and undevoiced morae, (2) the duration of a whole word with and without devoiced morae, and (3) the effect of the number of devoiced morae on the duration of a word.

EXPERIMENTAL METHODS

Six native speakers of Standard Japanese (2 male and 4 female) pronounced 41 test words containing 71 devoiceable vowels 3 times each in random order (41 test words x 3 times x 6 subjects = 738 tokens) containing 1328

devoiceable vowels. Their pronunciation of devoiceable vowels in the same words was not always consistent. When there was variation in the voicing of the same devoiceable vowel in the same word, the word was segmented and the segment durations were measured. 45 of the devoicing sites had voicing variations, excluding word-final position and pre-pausal position. The duration of moraic consonants were compared with that of corresponding CV morae. One female subject did not show any voicing variation. Therefore the results do not include her data. The comparison of duration was made only in the same mora in the same word uttered by the same speaker. All words which had voicing variation were segmented using the SUN Waves+ package.

RESULTS AND DISCUSSION

Durational ratio between moraic consonants and CV morae

The durational ratios between moraic consonants and corresponding CV morae was calculated. Two sets of measurements were taken for each devoicing site: for example, if a vowel in a word was devoiced in one utterance (p) and voiced in the other two utterances (q) and (r), two ratios (p/q) and (p/r) were calculated; if a vowel was devoiced in two utterances (x) and (y) and voiced in the other utterance (z), two ratios (x/z) and (y/z) were obtained. The period of aspiration after plosives was included as a part of plosives. The results are listed in Table 1.

Table 1 Average ratio by preceding consonants

consonant	No. of samples	mean ratio	SD
plosives	48	85.9 %	13.05
fricatives	16	88.0 %	14.96
Affricates	26	77.7 %	12.42
TOTAL	**90**	**83.93 %**	**13.97**

Statistical analysis by one-way ANOVA showed that the difference in the durational ratio between /CV/ morae and moraic consonants among the three types of preceding consonants was significant [$F(2, 87) = 4.002$, $p < .025$].

There were 18 out of 90 cases [45 sites x 2 comparisons] (20%) where moraic consonants were longer than CV morae: plosive [k] 8 out of 48 cases (16.7 %), affricates [tɕ] and [ts] 8 out of 16 cases (50 %), and fricative [ɕ] and [ɸ] 2 out of 26 cases (7.7 %). The average ratio of moraic consonants against CV counterparts was 83.93% (SD 13.97).

Figure 1 shows the mean duration of moraic consonants and consonants and vowels in CV morae averaged by all types of moraic consonants.

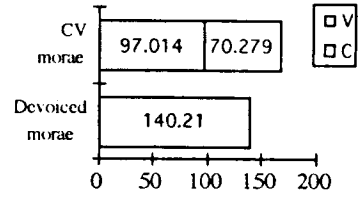

Figure 1 Average durational difference between moraic consonants and consonants and vowels in CV morae of all types of preceding consonants

The T-test (related) results showed that when the high vowels were devoiced, the remaining consonant in the same mora was significantly shorter than the equivalent CV mora, regardless of the type of preceding consonants: plosives [$t(23)=5.78$, $p<.001$], affricates [$t(7)=2.62$, $p<.025$], fricatives [$t(12)=6.62$, $p<.001$], and total [$t(44)=8.49$, $p<.001$].

Secondly, the duration of moraic consonants was also compared with the duration of non-moraic consonants in corresponding CV morae using T-test (related). The result found that the moraic consonants were significantly longer than the non-moraic consonant: plosives [$t(23)=11.93$, $p<.001$], affricates [$t(7)=9.26$, $p<.001$], fricatives [$t(12)=4.74$, $p<.001$], total [$t(44)=13.62$, $p<..001$]. In other words, the moraic consonants were significantly shorter than the equivalent CV morae, but at the same time they were significantly longer than the consonants in corresponding CV morae.

Considering the average ratio between the moraic consonants and the CV morae shown in Table 1, the moraic consonants were 83.93% of CV morae in duration compared to the prevocalic consonants which occupied 57.99% of whole CV duration. Comparing the moraic consonants and the prevocalic consonants, the moraic consonants were on average 44.53% longer than the prevocalic counterparts. In other words, there does appear to be some lengthening of consonants when the following vowels are devoiced and they become moraic, but it does not fully compensate for the reductions caused by the vowel devoicing.

Comparison of closure durations

The closure durations of moraic plosives and the plosive part of moraic affricates were compared with the closure durations of non-moraic plosives and the plosive part of non-moraic affricates. As shown in Figure 2, the average closure duration of plosives and affricates in CV morae was 56.16 ms (SD = 22.70), and that in devoiced morae was 57.16 ms (SD = 24.22). The T-test result (two-tailed) showed that the difference in the durations was not significant [t (31)=-0.51, n.s.]. However, the duration after the release of stop closure and fricative part of affricates in devoiced morae, and the added duration of these frication parts and the following vowel were very different.

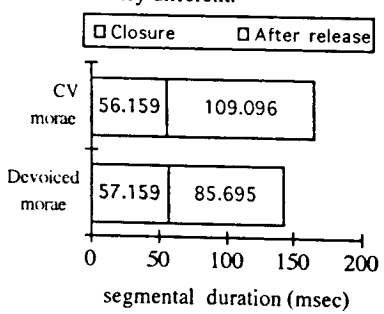

Figure 2 Average closure duration and the duration after release of plosives and plosive part of affricates in CV morae and devoiced morae

The average duration of moraic plosive and affricates, excluding closure duration was 85.70 ms (SD = 24.36), whereas that of CV morae excluding closure duration of the consonants was 109.10 ms (SD = 25.16). The statistical analysis by T-test (one-tailed) found the difference between them was significant [t(31)=7.12, p<.005]. The results suggested that although the durations of whole morae differed significantly, depending whether the vowel was voiced or devoiced, the closure durations of moraic plosives and affricates, and non-moraic counterparts did not show significant difference.

This suggests that the consonant was not actually lengthened, but rather vowel portion is hidden and it only appears as if consonant had been lengthened, as suggested by Jun and Beckman (1993) [4].

Durational adjustment within a mora

Devoiced morae were about 84% of the duration of /CV/ morae, which was a much higher proportion than the result obtained by Beckman (1982) [1]. One possible reason for this high proportion is the duration of the voiced vowels in /CV/ morae. The durational data for /CV/ morae in my experiment included partially voiced vowels which usually had a much shorter duration than their fully voiced counterparts. This might have brought the average duration of /CV/ mora down.

On the other hand, if there is durational adjustment within a mora in order to maintain the duration of each mora more or less similar, the shorter duration of partially voiced vowels should not affect the duration of whole /CV/ morae. The relationship between consonant and vowel durations within a mora was studied.

Although generally there was a tendency of negative correlation, the statistical analysis found the result was not significant [r(64)=-0.196, n.s.]. There seemed to be no durational adjustment between the durations of a consonant and a vowel within the same mora to keep the mora duration equal.

Devoicing and reality of mora-timing

The above results showing shorter durations of devoiced morae meant that the durations of voiced morae would also have to be adjusted to agree with the moraic duration theory of Port et al (1987). Therefore, the durations of whole words were measured and examined with relation to (i) the number of morae in a word, and (ii) the number of devoiced morae in a word.

Since the test words were pronounced in citation, the last mora of a word was usually lengthened, and the duration of the word initial stop closure and the beginning of fricatives were not always clear. Therefore, the durations of whole words were not exact measurements. However, there was a tendency for the duration of a whole word to lengthen as the number of morae in the word increased.

The number of morae in a word varied from 4 to 7, and the number of devoiced morae in a word varied from 0 to 3. Statistical analysis by ANOVA (3-way) found that the word durations were significantly influenced by the subjects [(F(4,81), p<.001] and the number of morae in a word [F(3,81), p<.001], but the effect of the number of devoiced vowels in a word was not significant [F(3,81), n.s.]. There was a significant interaction between subjects and the number of morae [F(10,81), p<.001].

The word durations of each number of morae were analysed using ANOVA (2-way) by the subject and the number of devoiced morae as the factors. The results shown in Table 2 found that for all numbers of morae in a word (4 to 7 morae), the effect of subjects was significant but the effect of the number of devoiced morae was not significant. No significant interaction between the numbers of morae in a word and devoiced morae was found.

Table 2 The ANOVA results of the effects of factors on word duration

No. of morae	Factor	
	Subject	No. of devoiced morae
4	F(3,19), P<.01	F(2,19), n.s.
5	F(4,20), P<.001	F(3,20), n.s.
6	F(3,12), P<.001	F(3,12), n.s.
7	F(4,30), P<.001	F(2,30), n.s.

The statistical results showed that the number of devoiced morae in a word was not an important factor for the whole duration of words. Rather it was the number of morae in a word and individual speakers that significantly influenced the whole duration of words. This may imply that the shorter durations of devoiced morae were adjusted at a word level so that the whole duration of a word does not have to change too much as Port et al (1987) [5] demonstrated.

CONCLUSIONS

Durational measurements of devoiced and /CV/ morae showed that devoiced morae were significantly shorter than /CV/ morae: proposed tendency of equalising mora duration was not tenable in devoiced morae. On the other hand, the number of devoiced morae in a word did not affect the duration of a word. That implies that shorter durations of devoiced morae were adjusted not within a mora but beyond the mora as suggested by Port et al (1987) [5]. Measurement of closure duration of stops suggested that the fairly high proportion of devoiced morae against /CV/ morae was not due to the compensatory lengthening of moraic consonant, but because the devoiced vowel was underlying as proposed by Jun and Beckman (1993) [4]..

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