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 was 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 language. 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. Therefore, the results from the above studies show 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 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 show 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 the 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 devoiceable sites had voicing variations, excluding word-final position and pre-pausal position. The duration of moraic consonants was 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

1. 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 devoiceing site: for example, if a vowel in a word was voiced in one utterance (q), its duration was adjusted and the word duration was fairly constant dependent on the number of morae in the word.

If 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 show 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?.

The result found that 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 consonants: plosives [t(23)=11.93, p<.001], fricatives [t(12)=4.74, p<.001], and total [t(44)=13.62, p<.001]. In other words, the moraic consonants were significantly shorter than the equivalent CV mora, but at the same time they were significantly longer than the consonants in corresponding CV morae.

Table 1: Average ratio by preceding consonants

<table>
<thead>
<tr>
<th>Consonant</th>
<th>No. of samples</th>
<th>Mean ratio</th>
<th>SD</th>
</tr>
</thead>
</table>
| 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].
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 prevoicic consonants which occupied 57.99% of whole CV duration. Comparing the moraic consonants and the prevoicic consonants, the moraic consonants were on average 44.53% longer than the prevoicic 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 \( t(31) = 0.51, \text{n.s.} \). 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.

**Duration 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 (a) the number of morae in a word, and (b) 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 \( F(4,81), \text{p}<.001 \) and the number of morae in a word \( F(3,81), \text{p}<.001 \), but the effect of the number of devoiced morae \( F(2,79), \text{n.s.} \) was not significant \( F(3,81), \text{n.s.} \). There was a significant interaction between subjects and the number of morae \( F(10,81), \text{p}<.001 \).

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

<table>
<thead>
<tr>
<th>No. of morae</th>
<th>Factor</th>
<th>No. of devoiced morae</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subject</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td>F(1,19), \text{p}&lt;.01</td>
<td>F(2,19), \text{n.s.}</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>5</td>
<td>F(3,20), \text{p}&lt;.001</td>
<td>F(2,20), \text{n.s.}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>F(4,12), \text{p}&lt;.001</td>
<td>F(3,12), \text{n.s.}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>F(4,30), \text{p}&lt;.001</td>
<td>F(2,30), \text{n.s.}</td>
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<td></td>
</tr>
</tbody>
</table>

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 word 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/ was not due to the compensatory lengthening of the consonant, but because the devoiced vowel was underlyingly as proposed by Jun and Beckman (1993) [4].

**REFERENCES**