# Durational evidence of the psychological reality of the mora in Japanese speakers' French

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## ABSTRACT

This study investigated to what extent the timing organisation of a first language (L1) influences the production of a second language (L2). We studied the timing compensation phenomenon as a tool for analysis of rhythmic organisation. Previous phonetic studies show that the mora is the basic unit of speech timing in Japanese, whereas in French the duration of a phrase is dependent on the number of syllables. Durational data from sets of French phrases consisting of the same number of syllables spoken by Japanese and French speakers will be presented. Our hypothesis was that the timing compensation effects would appear on different levels in the two language groups. The results indicated that: 1) Japanese speakers parse foreign sound sequences into a Japanese speech unit, i.e. the mora; and 2) in production they use the mora rather than the syllable for durational control of French when they speak French.

## 1. INTRODUCTION

The organisation of prosody, especially the timing of speech is important in terms of intelligibility of speech. It seems that listeners' tuning into timing organisation is a fine one. A study showed that native speakers' judgement on intelligibility of an utterance improved significantly, despite quite different acoustic features of the segments, by manipulating only its temporal features [1].

However, temporal organisation of speech is difficult for L2 learners because it varies from language to language. In Japanese, the unit of speech rhythm is the mora; the durations of whole words are proportional to the number of morae, despite consisting of segments of different durations and also different numbers and structure of syllables [2]. This timing control is consistent even when vowels in a word are devoiced, despite the fact that morae with devoiced vowels are significantly shorter than the equivalent morae with fully voiced vowels [3]. A strong tendency to equalise the duration of morae was found in Japanese utterances. Durational compensation worked within CV sequences (a moraic unit) rather than V-C sequences (i.e. across a mora boundary) [4]. In Japanese, durational adjustment in proportion to mora count appears to operate more significantly at the word level. In French, it used to be believed that each syllable takes approximately

the same time, but there is tendency to equalize the phrase duration regardless of number of syllables that they contain [5]. Our results will show tendency to equalise the phrase duration containing the same number of syllables, hence, phrase level compensation for the numbers of syllables.

It seems that Japanese adult listeners parse incoming speech strings into morae. Several psycholinguistic studies supported moraic segmentation in Japanese. The main hypothesis in the previous studies was that speech is prelexically segmented into rhythmic units specific to each language [6, 7]. Hence, French is segmented into syllables; English into trochaic stress feet. Following previous studies for French and English, Otake et al. [8] and Cutler and Otake [9] examined moraic segmentation by Japanese native listeners by using target detection tasks. They concluded that Japanese listeners segment speech into morae whereas English listeners do not.

Moraic segmentation is not the only parsing found in Japanese. Rather, segmentation into the sub-unit of the syllable develops after syllabic segmentation. Meta-linguistic experimental results showed that Japanese speaking children's awareness for moraic segmentation developed after their awareness for syllabic segmentation, but before they had learned kana syllabary, which is a moraic writing system [10]. Another study also reported Japanese new-born babies' insensitivity to moraic segmentation [11].

It is, thus, interesting to test whether Japanese adult listeners employ moraic or syllabic segmentation when they attend to non-moraic languages like French or English. When durations of English vowels are altered by accent (cf. 'Interstress Interval'), Japanese listeners can only detect the change when it is large enough to shift from a long vowel (two morae) to a short vowel (one mora), or vice versa [12]. This shows that there is an underlying phonemic adaptation process in English vowels where English vowel distinctions are encoded by moraic segmentation.

## 2. BACKGROUND

Let us now explain the adaptation process underlying moraic count of foreign sound strings. Phonological study of Japanese adaptation of English words clearly indicates that some English vowel phonemes correspond to two morae and the others to one: *pita* |pɪtə| > /pita/ vs. *Peter*

|pi:tə| > /piita/ (| | indicates foreign input forms; / / indicates Japanese adapted forms in phonemic representation) [13]. There is another well-known moraic rendition in Japanese loanwords. Foreign words ending in a single consonant are perceived (regardless of phonetic duration of the final C) and adapted with consonant gemination: *pit* |pɪt#| > /pit.to/ [14]. The phonological interpretation that we adopt here for this phenomenon is that the prefinal lengthening is the result of alignment between the stem edge (#) and a syllable edge (**.**) [15] -- a cross-linguistically common process. A closer look at this phenomenon reveals that the same type of moraic lengthening is masked when a preceding vowel is already a long one: *Pete* |pi:t| > /pi:.to/. In both cases the prefinal syllables in adapted forms are heavy. We will call this 'prefinal lengthening' (see below).

Another factor adding extra morae (and for this matter, syllables) in Japanese rendition of foreign words is the syllabification of complex syllable structures. Since Japanese syllables allow only simple onsets and can be closed with the first half of a geminate or a nasal, the codas and clusters of foreign words are syllabified through vowel epenthesis: *extra* > /ekusutora/ (epenthesis underlined).

Phonemic correspondence and 'prefinal lengthening' create vowel or consonant gemination in Japanese adapted forms. Syllabification of stray consonants also creates morae. We suggest that when Japanese speakers process foreign words they do so using Japanese morae, and it should be possible to detect this process by analyzing foreign word utterances. We will test whether this durational compensation by mora is reflected in French phrases as spoken by Japanese learners. Our experimental materials exploit the differences introduced into pairs of phrases by these extra morae, when the phrases are parsed and produced by Japanese learners.

Let us explain more specifically the 'prefinal lengthening' in adaptations of French words. In Japanese, the following elements count as a mora: (C)(j)V; N (moraic nasal); first half of a geminate consonant; last half of a long vowel or of a diphthong. When a French word ends in a single consonant, in the adapted form the rime corresponding to this syllable is lengthened (a similar case is observed for word final obstruent-liquid clusters, while other word-final clusters do not trigger any lengthening). This prefinal syllable can be heavy in the following ways (lengthened rimes are underlined):

1. It ends in the first half of a geminate consonant: /arusjub<u>ekku</u>/ < <u>archevêque</u> |aRʃəvɛk| 'archbishop'.

2. It contains a long vowel: /madur<u>eenu</u>/ < <u>madeleine</u> |madlɛn| 'a type of cake'.

The type of lengthening obtained depends on two factors:

a) Nature of the consonant;

b) Whether the vowel is 'lengthening' or not (see below).

Below we give examples of consonant gemination, vowel lengthening and variation patterns.

(a) Voiceless obstruent:
When a French word ends in a voiceless obstruent, this obstruent is consistently geminated in the adapted output.

| <u>lac</u> | |lak| | 'lake' | /rakku/ |
| <u>mèche</u> | |mɛʃ| | 'lock' | /messju/ |

(a') Voiceless obstruent preceded by a lengthening vowel: There are special cases to add to the preceding one: when the vowel in the final closed syllable is spelled with more than one letter (<u>au</u>, <u>ou</u>, etc.) or with a circumflex accent (ê, â, etc.), the vowel can optionally lengthen instead of the consonant. We will call these vowels 'lengthening vowels'.

| <u>haute</u> | |ot| | 'high' | /ooto/ or /otto/ |
| <u>fête</u> | |fɛt| | 'party' | /ɸeeto/ or /ɸetto/ |

The variation in this particular case is explained as follows. The choice depends on whether the vowel is recognised by the speaker as a lengthening vowel or not. If it is, then, the vowel is lengthened; otherwise, the regular consonant gemination in (a) above applies.

The lengthening vowels can be optionally adapted as a long vowel in any position. It is considered as a case of phonemic duration for some speakers apparently deviated by orthography.

(b) Voiced fricative:
When the final consonant is a voiced fricative, it is always the vowel that is lengthened.

| <u>rose</u> | |Roz| | 'rose' | /roozu/ |
| <u>terre</u> | |tɛR| | 'earth' | /teeru/ |

c) Voiced plosive or nasal stop, variation patterns:

| <u>robe</u> | |Rɔb| | 'dress' | /robbu/ or /roobu/ |
| <u>aide</u> | |ɛd| | 'help' | /eddo/ or /eedo/ |
| <u>pomme</u> | |pɔm| | 'apple' | /pommu/ or /poomu/ |
| <u>reine</u> | |Rɛn| | 'queen' | /rennu/ or /reenu/ |

Along with Japanese syllabification of illegal French syllable types, the prefinal lengthening creates specific timing counts in Japanese speakers' French utterances.

## 3.    EXPERIMENT

An experiment was carried out in order to examine how Japanese speakers parse French sound sequences into Japanese and the effects on their French utterances. If the sound perceptions of Japanese speakers depend on morae, they should also analyse French sound sequences by mora count and this will be apparent in their French utterances.

Six pairs of French phrases listed in (1) ~ (2) below were chosen for the experiment. The phrases in each pair consist of the same number of syllables. However, the phrases are potentially analysed into differing numbers of morae by Japanese speakers according to the rules in section 2 above. The typical phonological interpretation of each French phrase by Japanese speakers is presented below with the number of morae in brackets. This difference in mora number may influence the French phrase duration because

Japanese phrase duration is proportional to the number of morae. Here the commas indicate mora boundaries.

(1) 5 syllable phrases
1a. *le muscat perdu*    'the lost muscat'
        (Jp) /ru, mu,su,ka, pe,ru,dju/  (7)
1b. *le musc a perdu*    'the musc is lost.'
        (Jp) /ru, mu,su,ku, a, pe,ru,dju/ (8)
2a. *le ferret français*        'the French metal tag'
        (Jp) /ru, fe,re, fu,ra,N,se/ (7)
2b. le fer est français        'that iron is French.'
        (Jp) /ru, fe,e,ru, e, fu,ra,N,se/ (9)
3a. *le couplet complet*        'the complete verse'
        (Jp) /ru, ku,(p),pu,re, ko,N,pu,re/ (8~9)
3b. *le couple est complet*    'the couple is complete.'
        (Jp) /ru, ku,p,pu,ru, e, ko,N,pu,re/ (10)


(2) 6 syllable phrases
4a. *les garçons dessinés*    'boys who were drawn'
        (Jp) /re, gja,ru,so,N, de,si,ne/        (8)
4b. *les gares sont dessinées*
        'the stations that are being drawn'
        (Jp) /re, gja,a,ru, so,N, de,si,ne/    (9)

5a. *l'otarie dans le puits*  'the sea lion in the well'
        (Jp) /ro,ta,ri, da,N, ru, pju,i/        (8)
5b. *l'eau tarit dans le puits* 'water in the well is drying up'
        (Jp) /ro,o, ta,ri, da,N, ru, pju,i/  (9)

6a. *le touret compliqué*  'the complicated travel plan'
        (Jp) /ru, tu,(u), re, ko,N,pu,ri,ke/        (8~9)
6b. *le tour est compliqué*  'the trip is complicated.'
        (Jp) /ru, tu,u,ru, e, ko,N,pu,ri,ke/ (10)

The experiment was carried out in Paris and Tokyo. Five native speakers of French living in Paris and seven native speakers of Japanese who speak fluent French took part in the experiment. The French speakers' recordings were made in an anechoic room of Laboratoire de Psychologie Expérimentale in Paris and Japanese speakers' recordings were done in an anechoic room of Waseda University in Tokyo. However, only the data of 3 out of 7 Japanese speakers were used for the analyses, because the other four speakers often inserted pauses between a test phrase and the carrier sentence. Therefore, the data of these four Japanese subjects were excluded from the results of this study. The test phrases were presented in the carrier sentence '*Je dis test phrase neuf fois.*' ('I say ___ nine times'). The whole durations of the test phrases were measured from the end of the vowel /i/ of *dis* /di/ to the beginning of /n/ of *neuf* /nœf/ of the carrier sentence. Subjects were asked to pronounce the phrases three times, each presented randomly. The recorded data were digitised at the sampling rate of 32,000 Hz and analysed using xwaves+ on linux.

## 4.    RESULTS AND DISCUSSION

Average durations of test phrases by five French speakers and those of three Japanese speakers were calculated and analysed according to the number of syllables in the phrases and presented in Tables 1~4.

**Table 1  French speakers: 5 syllable phrases**

| French phrases | Mora count | Phrase duration |
|---|---|---|
| *le muscat perdu* | 7 | 863.64   ms |
| *le musc a perdu* | 8 | 856.34   ms |
| *le ferret français* | 7 | 920.78   ms |
| *le fer est français* | 9 | 891.25   ms |
| *le couplet complet* | 8~9 | 898.18   ms |
| *le couple est complet* | 10 | 889.63   ms |

**Table  2. French speakers: 6 syllable phrases**

| French phrases | Mora count | Phrase duration |
|---|---|---|
| *les garçons dessinés* | 8 | 1031.51  ms |
| *les gares sont dessinnées* | 9 | 966.39   ms |
| *l'otarie dans le puits* | 8 | 944.47  ms |
| *l'eau tarit dans le puits* | 9 | 995.83  ms |
| *le touret compliqué* | 8~9 | 986.16  ms |
| *le tour est compliqué* | 10 | 945.42 ms |

**Table 3.  Japanese speakers: 5 Syllable Phrases**

| French phrases | Mora count | Phrase duration |
|---|---|---|
| *le muscat perdu* | 7 | 1050.79  ms |
| *le musc a perdu* | 7* | 1090.36  ms |
| *le ferret français* | 7 | 1090.62  ms |
| *le fer est français* | 8* | 1162.63  ms |
| *le couplet complet* | 8~9 | 1140.30  ms |
| *le couple est complet* | 9* | 1144.81  ms |

**Table 4. Japanese speakers: 6 Syllable Phrases**

| French phrases | Mora count | Phrase duration |
|---|---|---|
| *les garçons dessinés* | 8 | 1,154.63  ms |
| *les gares sont dessinnées* | 9 | 1,262.97  ms |
| *l'otarie dans le puits* | 8 | 1,128.80  ms |
| *l'eau tarit dans le puits* | 9 | 1,263.17  ms |
| *le touret compliqué* | 8* | 1,183.56  ms |
| *le tour est compliqué* | 9* | 1,277.54  ms |

* Actual mora count by pronunciation

Statistical analysis by T-test comparing the whole durations of the phrases in each pair by French speakers found that there was no significant difference in any of the pairs (Table 5). Japanese speakers' durational data were also analysed by T-test and also showed no significant differences between pairs of phrases (Table 6).

**Table5. T-test (two-tailed) results by French speakers**

|  | 5 syllable phrases |  | 6 syllable phrases |
|---|---|---|---|
| 1a-1b | t(8) = 1.00, n.s. | 4a-4b | t(8) = 0.94, n.s. |
| 2a-2b | t(8) = 0.27, n.s. | 5a-5b | t(8) = -1.27, n.s. |
| 3a-3b | t(8) = 0.17, n.s. | 6a-6b | t(8) = 1.11, n.s. |

**Table6. T-test (one-tailed) results by Japanese speakers**

|  | 5 syllable phrases |  | 6 syllable phrases |
|---|---|---|---|
| 1a-1b | t(4) = -0.38, n.s. | 4a-4b | t(4) = -0.70, n.s. |
| 2a-2b | t(4) = 0.41, n.s. | 5a-5b | t(4) = 0.18, n.s. |
| 3a-3b | t(4) = 0.03, n.s. | 6a-6b | t(4) = 0.62, n.s. |

However, there were some interesting trends observed in the results. First of all, the number of morae did not have any influence on the utterances of French speakers. Often, in a pair of phrases the one with the higher mora count had shorter duration. In contrast, with the Japanese speakers the phrase with the higher mora count was usually the longer utterance. It is probable that the small sample number contributed to the lack of significance in the statistical analyses.

Moreover, only 4 pairs (pairs 2, 4, 5 and 6) among the test phrases actually differed clearly in the mora count. Other pairs could be parsed into the same number of morae depending on the interpretation of speakers (see (1) and (2)). The difference in the durations was relatively bigger in these four pairs compared with the other two. Since all three of the Japanese subjects were fluent speakers of French, they did not insert a vowel between every single consonant cluster. In phrases 1b, 2b, 3b, and 6b the word-final consonant was followed by a word-initial vowel, and the sequence was re-syllabified. Therefore there was no vowel insertion after the word-final consonant, and the actual mora count for these phrases was smaller than expected (Tables 3 and 4). In the phrases 2b and 6b, however, the vowels in the words *fer* and *tour* came before the word-final /r/ and could be interpreted as 2 morae, which would have caused durational differences. With regard to phrase 6a, all the Japanese speakers pronounced *touret* with two morae as /tu,re/ rather than with three morae as /tu,u,re/. Consonant gemination of the /p/ in *couple* also increased the mora count. As for phrases 1a and 1b, the vowel /u/ could not be analysed as two morae in either *muscat* or *musc*. Since the Japanese subjects re-syllabified the final /k/ with the following /a/, the mora count of both 1a and 1b were the same. Hence there was relatively little difference in their durations.

## 5. CONCLUSIONS

The experimental results suggest that Japanese speakers parse foreign sound sequences by the mora, and also use the mora, rather than the syllable for durational control when they speak French. This tendency was typically clear in the experimental environments where the French vowels were analysed as potentially bimoraic.

Interestingly, the additional mora in phrases only increased the durations when it was introduced either by phonemic correspondence or 'pre-final lengthening', but not by syllabification of a stray consonant. It seems that vowel epenthesis could be eliminated by our subjects, who were proficient in French, but even so it is clear that rhythmic control in an L2 timing unit is difficult to acquire.

Despite the lack of significant differences in durations obtained in this study, we still feel that moraic analysis by either phonemic correspondence or 'pre-final lengthening' is still robust. Further research is in progress with more subjects.

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