

# LISTENERS' REPRESENTATIONS OF WITHIN-WORD STRUCTURE: JAPANESE PRESCHOOL CHILDREN

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## ABSTRACT

This study investigated how Japanese preschool children represented within-word structure, focusing on two phonological units, syllables and moras. The main question addressed in this study was how the acquisition of Japanese kana orthography influenced the choice of these units. The results of the three experiments showed that preschool children who were illiterate preferred syllable-sized representation and that the acquisition of kana syllabary facilitated to choose mora-sized representation for words containing a moraic nasal, but did not for words containing a geminate consonant and a long vowel.

## 1. INTRODUCTION

It is generally assumed that understanding the process of word recognition needs to examine two questions. The first question is how human listeners extract the acoustic-phonetic information from the speech signal. Researchers have conducted intensive investigations to find answers for these questions during the past decade. One remarkable finding in the recent speech segmentation studies has revealed that human listeners exploit rhythm-based speech segmentation strategies that are based upon linguistic rhythm [1]. According to this claim, human listeners segment continuous speech with a unit that is related to linguistic rhythm such as syllables, stress and moras. The experimental studies showed that listeners of variety of languages exploited the rhythm-based speech segmentation strategies [2][3][4][12][13].

The second question is how words are stored in the mental lexicon. If a word recognition process is considered as a mapping process of the acoustic-phonetic information onto the stored knowledge, it is important to investigate how human listeners form conscious representations of potential within-word structure. A previous explicit-segmentation study on English and Japanese showed that Japanese listeners could use syllables to represent words [11]. This is also true for Japanese-English bilinguals and American-English natives who learn Japanese [14][17]. In addition, Japanese-Brazilian listeners also used syllables to represent unknown Japanese words [15]. Syllables are widely used to represent within-word structure across languages. Although it is often reported that Japanese words are also represented by moras [8], theoretically, moras and syllables coexist in the mental lexicon because it stores all phonological information [9]. Japanese adult listeners may be more conscious to moras than syllables.

This moraic consciousness by Japanese adult listeners could be highly associated with the orthographic representations of words in the lexicon. It is reported that acquisition of the orthographic system may enhance children to be conscious to moras [8]. Thus, one possible hypothetical interpretation of

previous explicit-segmentation results with Japanese adult listeners is that they were somehow more sensitive to moras rather than syllables because the consciousness of moras may have been enhanced by kana representation. If this hypothesis is correct, Japanese listeners who do not have knowledge of the orthographic system may not have strong consciousness of moras. In such a case, they should be more sensitive to syllables rather than moras.

The present study aimed at investigating the representations of within-word structure with Japanese preschool children. Children at a nursery school who had not yet learned the Japanese orthographic system formally were tested. The primary interest in this study was to investigate how Japanese preschool children represented three types of Japanese words, *manga*, *koppu*, and *koori*, each of which has two different phonological representations in terms of syllable and moras. Most moras are coincided with syllables. Thus, the number of moras and syllables in a word like *kasa* is identical (2-mora or a 2-syllable). However, the examples above have two possible representations depending upon which phonological unit is chosen.

Thus, there are two predictions about performance of Japanese preschool children in this study. If the acquisition of the kana orthographic system affects the representation of within-word structure, Japanese preschool children may show their preference to mora-sized representation (*ma.n.ga*, *ko.p.pu*, and *ko.o.ri*) rather than syllable-sized representation (*man-ga*, *kop-pu*, and *koo-ri*). On the other hand, if the acquisition of the kana orthographic system does not affect the representation of within-word structure, Japanese preschool children may not choose the moraic representation (*ma.n.ga*, *ko.p.pu*, and *ko.o.ri*), which eventually brings more responses to syllable-sized representation (*man-ga*, *kop-pu*, and *koo-ri*) rather than mora-sized representation. Since they have not yet acquired the kana orthographic system, the consciousness of the moraic representation may not be developed.

Three experiments were designed to test the hypothesis using the different set of materials. In Experiment 1 stimuli containing a nasal in the coda of the first syllable were used (e.g., *manga*). In Experiment 2 stimuli containing a geminate consonant within a word were used (e.g., *koppu*). In Experiment 3 stimuli containing a long vowel in the first syllable were used (e.g., *koori*).

## 2. EXPERIMENT 1

### 2.1. Method

Materials consisted of 20 stimuli and 25 fillers, which are Japanese familiar words used in picture books for children. Stimuli were 2-syllable 3-mora words, each of which included a moraic nasal word medially (e.g., *manga*). Fillers were 1 to 4

mora words, none of which contained a nasal in the coda of the first syllable. Stimuli were submitted to statistical analyses.

Prior to the experiment 1, participants were tested their kana literacy using the kana literacy test developed by the National Institute of Japanese Language. This test consists of two sections. The first section tests whether children can read single kana characters (N=71). A character representing a moraic nasal is one of them. The second section consists of words and sentences. Characters representing a geminate consonant and a long vowel are included in it. Notice that geminate consonants and long vowels are only expressed within a word. In other words, recognition of the kana characters is not sufficient in order to be able to identify geminate consonants and long vowels. Children have to learn the relationship between the characters within a word.

The materials were presented orally by a female speaker of Tokyo dialect. Children were instructed to listen to each word and clap their hands or hit with a plastic hammer [10]. During the practice session, a nonsense syllable [pa] was repeated from one to as many as four to each subject to see if they could count the number of chunks appropriately. The entire experiment was videotaped. They were tested individually in a quiet room. The decision of response pattern was based on the number of their hits for each stimulus word. If they hit twice, it was identified as a syllable-sized unit, while if they hit three times, it was identified as a mora-sized unit.

Participants were 38 Japanese preschool children attending a nursery school in Kanagawa in Japan (mean age = 5 years 3 months; range = 3, 8 to 6, 3).

## 2.2. Results and Discussion

The percentages of choices for mora-sized and syllable-sized units for all participants are shown in Table 1. Proportion of response types was submitted to paired t-tests. An overall analysis showed that participants preferred syllable-sized choices (i.e. *man* in *man-ga*) to mora-sized choices (i.e., *ma* in *ma.n.ga*) ( $t1[37] = -3.61, p < .001; t2[19] = -61.77, p < .001$ ).

	Mora-sized	Syllable-sized
All participants	25%	75%

Table 1. The percentages of choices of two phonological units.

For further analyses, 38 children were first divided into two groups based on the kana literacy test (Levels 1 and 2). 9 children who had extensive reading ability were grouped into Level 2, and the rest into Level 1. Children at Level 1 were further divided into two groups, Level 1A and Level 1B, based upon the recognition of the kana character representing a moraic nasal. Level 1A was the group of children who could not recognize it but who identified 26 characters on the average. Level 1B was the group of participants who could recognize it and who identified 56 characters on the average.

The percentage of choices of two phonological units for the three levels are shown in Table 2. Children at Levels 1A and 1B showed that syllable-sized responses were higher than mora-sized responses (Level 1A:  $t1[13] = -101.57, p < .001, t2[19] = -100.25, p < .001$ ; Level 1B:  $t1[14] = -3.86, p < .002, t2[19] = -49.46, p < .001$ ). However, children at Level 2 showed the opposite pattern. They showed that mora-sized responses were

higher than syllable-sized responses ( $t1[8] = 2.16, p < .063, t2[19] = 21.92, p < .001$ ).

	Mora-sized	Syllable-sized
Level 1A (N=15)	1%	99%
Level 1B (N=14)	15%	85%
Level 2 (N=9)	79%	21%

Table 2. The percentages of choices of two phonological units.

The results in Experiment 1 revealed two things. First, the overall analysis showed that Japanese preschool children preferred to represent Japanese words in terms of syllable rather than moras. Second, analyses within levels showed that the response patterns of preschool children seemed to be more complicated than we expected. There was a clear distinction between Level 2 and the rest because the response pattern clearly changed from syllable-sized responses to mora-sized responses. The increased percentage of mora-size responses from Level 1A to Level 1B implies that the recognition of the kana character representing a moraic nasal seems to enhance the recognition of a moraic nasal. However, the identification of this character is not sufficient to be sensitive to moras over syllables. It seems that the more important factor is extensive reading experience.

## 3. EXPERIMENT 2

### 3.1 Method

Stimuli were 20 2-syllable 3-mora words, each of which included a geminate consonant word medially (e.g., *koppu*). The rest was the same as in Experiment 1.

### 3.2. Results and Discussion

The percentages of choices for mora-sized and syllable-sized units for all participants are shown in Table 3. The analysis showed a main effect of phonological units: syllable-sized choices (i.e., *kop* in *kop-pu*) were selected more frequently than mora-sized choices (i.e., *ko* in *ko.p.pu*) ( $t1[37] = -9.64, p < .001; t2[19] = -69.63, p < .001$ ).

	Mora-sized	Syllable-sized
All participants	9%	91%

Table 3. The percentages of choices of two phonological units.

38 participants were divided into two groups (Levels 1 and 2), as in Experiment 1. The percentages of choices of the two phonological units for the two levels is shown in Table 4. Children at both levels showed that syllable-sized responses were higher than mora-sized responses (Level 1:  $t1[28] = -13.38, p < .001, t2[19] = -5461, p < .001$ ; Level 2:  $t1[8] = -1.87, p < .098, t2[19] = -21.48, p < .001$ ).

	Mora-sized	Syllable-sized
Level 1 (N = 29)	4%	96%
Level 2 (N = 9)	25%	75%

Table 4. The percentages of choices of two phonological units.

The results of this experiment showed that Japanese preschool children were sensitive to syllable-sized units rather than mora-sized units. This may indicate that their

representations are likely to give more priority to syllables.

#### 4. EXPERIMENT 3

##### 4.1 Method

Stimuli were 2-syllable 3-mora words, each of which included a long vowel word medially (e.g., *koori*). The rest was the same as in Experiment 1.

##### 4.2. Results and Discussion

The percentages of choices for mora-sized and syllable-sized units for all participants are shown in Table 5. The analysis showed a main effect of phonological units: syllable-sized choices (i.e. in the case of *booru*, *boo-*) were selected more frequently than mora-sized choices (*bo-*) ( $t[37] = -10.21$ ,  $p < .001$ ;  $t2[19] = -30.61$ ,  $p < .001$ ).

	Mora-sized	Syllable-sized
All participants	9%	91%

Table 5. The percentages of choices of two phonological units.

38 participants were divided into the two groups (Levels 1 and 2), as in Experiment 1. The percentages of choices for mora-sized and syllable-sized units for all participants are shown in Table 6. Children at both levels showed that syllable-sized responses were higher than mora-sized responses (Level 1:  $t[28] = -10.38$ ,  $p < .001$ ,  $t2[19] = -54.61$ ,  $p < .001$ ; Level 2:  $t[8] = -3.29$ ,  $p < .02$ ,  $t2[19] = -30.61$ ,  $p < .001$ ).

An overall analysis showed that Japanese preschool children were sensitive to syllable-sized units rather than mora-sized units. The level analyses showed the same tendency. These results suggest that their representations are likely to give more priority to syllables.

	Mora-based	Syllable-based
Level 1	8%	92%
Level 2	14%	86%

Table 6. The percentages of choices of two phonological units.

#### 5. ANALYSES ACROSS EXPERIMENTS

Three experiments showed that Japanese preschool children are generally sensitive to syllables rather than moras. The data also provide some interesting implications on three types of moras. The data discussed in this section are based upon 9 children at Level 2. They had an ability to identify a moraic nasal, a geminate consonant, and a long vowel as well as sentences. The percentages of the mora-sized responses across the three experiments are shown in Table 7. The proportions of mora responses were submitted to ANOVAs.

	Moraic nasal	Geminate	Long vowel
Level 2 (N=9)	80%	24%	13%

Table 7. The percentages of the mora-sized responses across Experiments 1 and 3.

The one-way analysis of variance showed that the response pattern of three types of moras was different ( $F1[2, 24] = 7.79$ ,  $p < .0025$ ;  $F2[2, 57] = 837.193$ ,  $p < .0001$ ). Turkey-Kramer comparisons showed a significant difference between a moraic

nasal and a geminate and between a moraic nasal and a long vowel by subjects. They also showed its significance between a moraic nasal and a geminate, between a moraic nasal and a long vowel and between a geminate and a long vowel by items.

The results clearly indicate that Japanese preschool children responded to the three types of moras differently. A moraic nasal was identified more successfully than a geminate and a long vowel. Also, there seems to be a tendency that a geminate was identified more successfully than a long vowel, although there is still a clear large difference between a moraic nasal and the others. The results suggest that identification of three moras is not identical.

#### 6. GENERAL DISCUSSION

The present paper conducted three experiments with preschool children in order to test the hypothesis that the acquisition of kana orthographic system influences the choice of phonological units to represent within word structure. Experiment 1 showed that Japanese preschool children preferred to represent words like *manga* by syllables. However, further level analyses showed that children at Level 2, in fact, preferred to represent words by moras rather than syllables. The results of Experiments 2 and 3 both indicated that they preferred to represent words like *koppu* and *koori* by syllables rather than by moras. Further level analyses also showed the same tendency in both experiments. Collectively, the results indicate that Japanese preschool children prefer syllables to moras to represent within-word structure prior to the acquisition of extensive reading ability. This implies that their focus on representation with words shifts from the syllable representation to the moraic representation, as their language experience is deepened [7].

The data of Level 2 across Experiments showed that the acquisition of reading ability affects the representation of within-word structure, but only to the words like *manga*, which contains a moraic nasal. Children at Level 2 showed their mora preference in Experiment 1 but not in Experiments 2 and 3. This might indicate that children need enough experience in reading to represent words by moras. The data in Experiment 1 clearly showed that the identification of the kana character representing a moraic nasal is not enough to favor for the moraic representation within words, which is supported by a previous study [5]. However, the data also indicate that the affect of reading ability varies among three types of words used in this study. Recognition of moraic nasals in Experiment 1 seems to be highly affected by children's reading ability.

Analyses across experiments further indicate that Japanese preschool children did not perform consistently in the study. The second moras occurring in the first syllable within a stimulus word (such as *ma.n.ga*, *k.op.pu*, and *ko.o.ri*) were perceived differently, although it has been assumed that they are treated as the same. Their response pattern in Experiment 1 (moraic nasal) was different from the one in Experiments 2 and 3 (geminate consonants and long vowels). Why did they perform differently in the experiments? One possible explanation is that the results showed the characteristics of the stimulus differences across experiments. The data might show a clear distinction between moraic nasals and the rest (geminate consonants and long vowels). The latter may be purely defined by its duration, while the former category may be defined by other factors such as a

syllable position. Their response patterns might reflect the characteristics of stimuli. Another possible explanation is that the data showed the development of consciousness of moras in Japanese. The results might imply that moras are not equally identified. Moraic nasals are easier to be identified than geminate consonants and long vowels, which showed a clear perceptual distinction. Further geminate consonants are easier to be identified than long vowels. This difference might show their degree of consciousness of moras in Japanese. This interpretation may be adequate because it is frequently observed that non-native speakers of Japanese show the same tendency at the early stage of Japanese language learning. Experiments with elementary school children will provide us more data to determine which explanation is more plausible to describe the present data [16].

## 7. CONCLUSION

This paper investigated whether the acquisition of the kana orthographic system affects the within-word structures of Japanese preschool children. The results showed that Japanese preschool children preferred to represent words by syllables rather than by moras. The identification of the kana characters did not trigger their preference of moraic representation, although some previous studies have argued that identification of kana character influenced the recognition of moraic nasals in Japanese [8]. Our data showed that extensive language experience in reading affected their performance: Children who had a extensive reading ability showed their preference to the moraic structure. We conclude that the acquisition of the kana orthographic system is not enough to bring consciousness of moras in Japanese and Japanese preschool children are more sensitive to the syllable representation rather than the moraic representation. The consciousness of moras is enhanced by the acquisition of the orthographic system and by extensive reading experience, although this effect was restricted only in words containing a moraic nasal.

We have not yet figured out how our conclusion is related to the issue on the acquisition process of lexicon. Our data contradict to a prediction by segmentation studies assuming that Japanese children may form conscious representations with moras rather than syllables [1]. Our conclusion does not coincide with the findings in [6] which claims that a moraic structure may be developed prior to the acquisition of the kana orthographic system. Further investigation is needed.

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## REFERENCES

[1] Cutler, A. 1994. Segmentation problems, rhythmic solutions. *Lingua* 92, 81-104.

- [2] Cutler, A., Mehler, J., Norris, D.G. and Segui, J. 1986. The syllable's differing role: the segmentation of French and English. *Journal of Memory and Language*, 25, 385-400.
- [3] Cutler, A. and Norris, D. 1988. The role of strong syllables in segmentation for lexical access. *Journal of Experimental Psychology: Human Perception and Performance*, 14, 113-121.
- [4] Cutler, A. and Otake, T. 1994. Mora or phoneme? Further evidence for language-specific listening. *Journal of Memory and Language* 33, 824-844.
- [5] Dairoku, K. 1995. Moora ni taisuru ishiki wa kanamoji syuutoku no hitsuyoo joken ka? *Shinrigaku Kenkyuu* 66,253-260.
- [6] Ito, T. and Tatsumi, K. 1997. Tokusuyhaku ni taisuru metagengo chishiki no hattatsu. *Onsi Gengo Igaku* 38, 196-203.
- [7] Jusczyk, P. W. 1994. "Infant speech perception and the development of the mental lexicon," In J. C. Goodman and H. C. Nusbaum (Eds.) *The Development of Speech Perception*. 227-270. Cambridge: MIT Press.
- [8] Kubozono, H. 1996. Speech segmentation and phonological structure. In T. Otake & A. Cutler (Eds.) *Phonological Structure and Language Processing: Cross-linguistic Studies*, 77-94, Berlin: Mouton de Gruyter.
- [9] Levelt, W.J.M. 1989. *Speaking: From Intention to Articulation*. Cambridge, MA: MIT Press.
- [10] Liberman, I.Y., Shankweiler, D., Fischer, F. W. and Carter, B. 1974. Explicit syllable and phoneme segmentation in the young child. *Journal of Experimental Child Psychology* 18, 201-212.
- [11] Otake, T., Davis, S. and Cutler, A. 1995. Listeners' representations of within-word structure: A cross-linguistic and cross-dialectal investigation. *Proceedings of EUROPEECH 95*, Vol. 3, 1703-1706.
- [12] Otake, T., Hatano, G., Cutler, A. and Mehler, J. 1993. Mora or syllable? Speech segmentation in Japanese. *Journal of Memory and Language*, 32, 258-278.
- [13] Otake, T., Hatano, G. and Yoneyama, K. 1996. Speech segmentation by Japanese listeners. In T. Otake & A. Cutler (Eds.) *Phonological Structure and Language Processing: Cross-linguistic Studies*, 183-201, Berlin: Mouton de Gruyter.
- [14] Otake, T. and Yamamoto, K. 1997. Listeners' representations of within-word structure for bilingual Japanese speakers of English and monolingual speakers of Japanese and English. Paper presented at the 134<sup>th</sup> Meeting of the Acoustical Society of America, San Diego.
- [15] Otake, T. and Yoneyama, K. 1998. Phonological units in speech segmentation and phonological awareness. *Proceedings of International Conference on Spoken Language Processing 98*, Vol. 5, 2179-2182.
- [16] Otake, T. and Yoneyama, K. in preparation. Listeners' representations of within-word structure: the first graders of primary school.
- [17] Otake, T., Yoneyama, K. and Maki, H. 1998. Non-native listeners' representations of within-word structure. *Proceedings of the 16<sup>th</sup> International Congress on Acoustics and the 135<sup>th</sup> Meeting of the Acoustical Society of America*, Vol. 2, 2067-2068.