

## MORAIC STATUS AND SYLLABLE STRUCTURE IN SPEECH PERCEPTION

Takashi Otake\* and Kiyoko Yoneyama\*\*  
Faculty of Foreign studies, Dokkyo University\*  
Graduate School of Dokkyo University\*\*  
1-1, Gakuen-cho, Soka-shi, Saitama-ken, 340, Japan

### ABSTRACT

This paper investigates the role of syllable structure and allophonic variations of a nasal in Japanese speech perception. Two experiments are designed regarding recognition of the allophonic variations of a nasal in reference to syllable position. In the first experiment stimuli were designed in such a way that a moraic nasal preceding three stop consonants, /p, t, k/ was spliced and embedded in an onset of the first syllable of a word, /natsu/. In the second experiment stimuli were designed in such a way that a nasal from the five contexts was spliced and embedded in the coda position of three CVN words.

The results of these experiments suggest that moraic status is determined by position in a syllable.

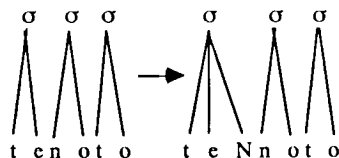
### 1. INTRODUCTION

A number of studies in speech production have revealed that the mora is the basic production unit in Japanese. Recent studies in speech perception have also demonstrated that the basic segmentation unit in Japanese is a mora [1][2]. The mora *per se* is usually defined by its unique durational characteristics, namely a constant duration, although the existence of an absolute durational unit is not necessarily agreed upon in the literature. Our recent investigations, however, have suggested that recognition of moraic consonants in speech perception is influenced by syllable structure as proposed by phonological analysis [3], as well as by duration [4] [5].

In the earlier works [4][5], we altered the duration of a nasal which was embedded both in a coda and an onset in a syllable. Unlike the findings in the study of production [6], even one tenth of the original nasal duration was perfectly recognized as a moraic nasal as long as it was embedded in a coda

position. On the other hand, when the nasal duration in an onset was increased to as long as 1.5 times the original one, a resyllabification process was observed (See (1)).

(1)



Thus, the added portion of the nasal was recognized as a moraic nasal in the preceding syllable. The results of these two experiments led us to conclude that determination of moraic status in speech perception may be highly related to position as well as to duration. These studies have led us to posit another interesting question concerning the relationship between moraic status and syllable structure. This paper reports the results of two experiments investigating the relationship between the allophonic variations of a Japanese nasal and syllable position.

### 2. EXPERIMENT I

In Experiment I, three variants of a nasal in coda position of a CVN syllable preceding three consonants (p, t and k) were spliced from three words (teNpo, teNto and teNko) and embedded in the onset of words (natsu, nasu, naku, nata). These stimuli were presented to Japanese listeners who were asked to transcribe them.

### 2.1 Method

#### 2.1.1 Materials

Twelve stimulus words were made from two groups of words, each of which contains a nasal in an onset or a coda. These are /natsu, nasu, naku, nata/ and /teNpo, teNto, teNko/. All these words were recorded at a normal tempo by a male native speaker of Tokyo Japanese. In order to avoid the effect of pitch accent, no accent was assigned. After recording, three stimuli for each word which has a nasal in an onset (natsu, nasu, naku, nata) were made by Kay Sona Graph 5500 in such a way that the nasal in onset position was cross-spliced with three allophonic nasals ([m], [n], [ŋ]), each of which occurs in the three nonsense words (teNpo, teNto, teNko), respectively. The duration of the spliced nasals in the stimulus words was the same as the original duration of the nasal in the original words (natsu, nasu, naku, nata). The portion of the vowel which exhibited nasalization was removed. Each of the twelve spliced words and the original four words (natsu, nasu, naku, nata) were recorded twice onto a tape with a two second inter-stimulus interval in random order.

#### 2.1.2 Subjects

Subjects were 30 students of Dokkyo University. The majority of the students were majoring in English who have basic knowledge of phonetics and phonology.

#### 2.1.3 Procedure

Each subject was instructed to listen to the stimuli, which were repeated twice, and to write down what they heard in Roman alphabet on a test sheet. They were instructed to write moraic nasals with a capital N. The stimuli were presented to each subject individually over headphone in a quiet room.

### 2.2 Results

The results of the experiment are shown in Fig. 1. As can be seen, the nasal spliced from the coda preceding /t/ which was embedded in the onset of nV-CV words was recognized as an alveolar nasal ( $\chi^2[1] = 120, p < .001$ ). The nasal spliced from the coda preceding /p/ embedded in the onset was recognized

as a bilabial nasal ( $\chi^2[1] = 90.1, p < .001$ ). However, when the nasal spliced from the coda preceding /k/ was embedded in the onset, it was simply recognized as an alveolar nasal ( $\chi^2[1] = 104.5, p < .001$ ).

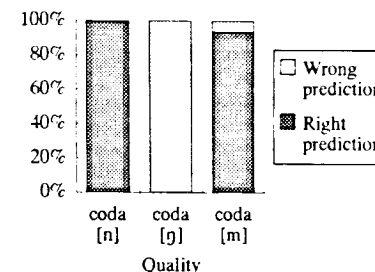


Figure 1. Identification functions for spliced nasal consonants in an onset position that differ in quality.

### 2.3 Discussion

Studies of Japanese phonology have claimed that as long as a nasal is placed in a coda position, it is automatically defined as moraic [3]. This may imply that moraic status is given to any nasal which is embedded in the coda position even in speech perception. Since the results of the present experiment have shown that the three different nasal qualities embedded in the onset were recognized either as an alveolar or a bilabial nasal, while if they were placed in the coda they were recognized as a moraic nasal, this phenomenon can be understood only if we assume that a nasal's moraic status is determined by its coda position. The reason why a nasal preceding a velar consonant embedded in the onset was reported as an alveolar nasal was simply because velar nasals do not occur in onset position in Japanese and there is no way to represent it in Roman alphabet.

### 3. EXPERIMENT II

In Experiment II, we investigated how a nasal in the coda in a CVN syllable preceding three different contexts (p, t and k) and a nasal in the onset (n and m) in the coda were recognized in order to confirm the findings of Experiment I. If coda

position is a decisive factor for a moraic status, all the nasals in the present experiment must be recognized as moraic.

### 3.1 Method

#### 3.1.1 Materials

Fifteen stimulus words were made from two groups of words, each of which contains a nasal in a coda or an onset. These are /teNpo, teNto, teNko/ and /natsu, matsu/. All these words were recorded at a normal tempo by a male native speaker of Tokyo Japanese. In order to avoid the effect of pitch accent, no accent was assigned. After recording, five stimuli for each word which has a nasal in a coda (teNpo, teNto, teNko) were spliced with a Kay Sona Graph 5500 in such a way that five allophonic nasals differently taken either from a coda (teNpo, teNto, teNko) or from an onset (natsu, matsu) were inserted into /teNpo, teNto, teNko/, respectively. The portion of the vowel which exhibited nasalization was removed. The duration of nasals from a coda (teNpo, teNto, teNko) was about 60 ms., and that of nasals from an onset (natsu, matsu) was not altered. Each stimulus word was recorded twice onto a tape with a two second inter-stimulus interval, in random order.

#### 3.1.2 Subjects

Subjects were the same as in Experiment I.

#### 3.1.3 Procedure

The procedure was the same as in Experiment I.

### 3.2 Results

The results in the three spliced words /teNpo, teNto, teNko/ are shown in Fig. 2, Fig. 3, Fig 4., respectively. As can be seen in the figures, nasals in coda position in the three spliced words were reported as moraic ( $\chi^2[1] = 208.3$ ,  $p < .001$  for teNpo;  $\chi^2[1] = 284.2$ ,  $p < .001$  for teNto;  $\chi^2[1] = 276.5$ ,  $p < .001$  for teNko). Each of five variations of a nasal was significantly more often judged as moraic ( $\chi^2[1] = 179.1$ ,  $p < .001$  for coda [m];  $\chi^2[1] = 160.6$ ,  $p < .001$  for coda [n];  $\chi^2[1] = 156.8$ ,  $p < .001$  for coda [ŋ];  $\chi^2[1] = 138.7$ ,  $p < .001$  for onset [m] and [n]. There was no significant

difference between the five nasal variation conditions.

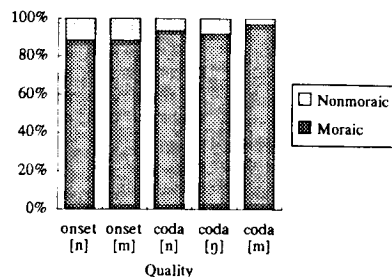


Figure 2. Identification functions for spliced nasal consonants in coda position that differ in quality in "teNpo".

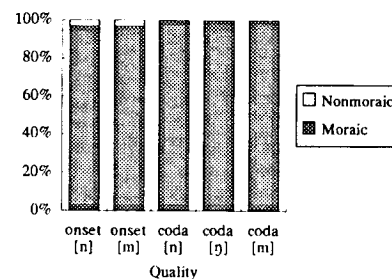


Figure 3. Identification functions for spliced nasal consonants in coda position that differ in quality in "teNto".

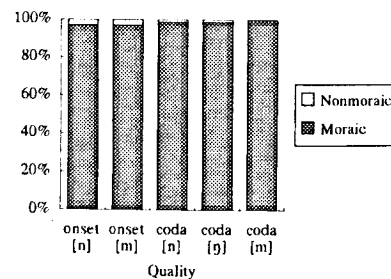


Figure 4. Identification functions for spliced nasal consonants in coda position that differ in quality in "teNko".

### 3.3 Discussion

The results in the present experiment have further confirmed the findings of Experiment I. Even though the nasals in the five different contexts must have different phonetic qualities, all were judged as a moraic nasal in coda position. It is obvious that syllable position plays an important role for recognition of the mora in Japanese.

### 4. GENERAL DISCUSSION

The two experiments in this study have clearly shown that recognition of a moraic nasal in speech perception in Japanese is dependent on syllable position. The results of Experiment I have shown that the three allophonic variations of a nasal, [m], [n] and [ŋ] were recognized as different in syllable initial position, while they were simply recognized as a moraic nasal if they were placed in the coda position.

The results of Experiment II have also confirmed that when the two nasals [m] and [n] in the onset and the three nasals in the coda in the CVN syllable were embedded in the coda of the initial syllable in /teNpo, teNto and teNko/, they were judged as an undifferentiated moraic nasal.

In previous studies in the literature of speech production and perception, moraic status has been investigated with respect to duration. On the other hand, in phonological analysis a mora is defined as a subunit of a syllable. The relationship between these two units has been intensively investigated by phonologists. If a mora is defined as a subunit of a syllable, it may be very likely that both mora and syllable structure play a role in speech perception. Our earlier studies have demonstrated that a speech segmentation procedure during on-line speech perception in Japanese must be based upon morae rather than on syllables [1][2]. However, a speech segmentation with an off-line speech perception task may be more complicated. Although we need further intensive examinations to clarify the problem, knowledge of syllable structure must be involved in speech perception.

### 5. CONCLUSION

In this paper, we have conducted two experiments in order to examine the relationship between the allophonic variations of a nasal and moraic status. We have claimed that moraic status is highly dependent upon syllable structure. In other words, moraic status is determined by a coda position. The results of this study have confirmed the findings in our previous studies, claiming that syllable structure plays an important role in speech perception in Japanese.

### ACKNOWLEDGMENT

This study was partly supported by a grant of the Ministry of Education (Grant number is 06610475). We would like to express our gratitude to A. Cutler, who has read the earlier manuscript and gave us many invaluable comments, and to G. Hatano and all other people participating in the experiments. We further thank K. Kurisu and M. Komada for their critical comments.

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