

A Moraic Nasal and a Syllable Structure in Japanese

Takashi Otake[†] and Kiyoko Yoneyama^{††}

[†]Faculty of Foreign Languages, Dokkyo University
^{††}Graduate School of Dokkyo University
1-1, Gakuen-cho, Soka-shi, Saitama-ken, 340, JAPAN

Abstract

In the previous study the recognition of a mora in Japanese during on-line speech perception was investigated independent of a syllable structure [1]. In this study the role of a syllable structure and the durational properties of a moraic nasal in Japanese during the off-line speech perception were explored. Three experiments regarding the recognition of a nasal were conducted. In the first experiment a reduced nasal duration in two positions, the onset and the coda were examined. The results have shown that the recognition of a nasal in the two positions can be accomplished irrelevant to the durational properties. In the second experiment, the relationship between the duration of a nasal and a syllable structure was examined. The results have shown that both the durational properties and a syllable structure played an important role in the recognition of a moraic nasal in Japanese. In the third experiment, it was tested how Dutch listeners recognized the nasal in the Japanese materials. The results have shown that their recognition system differed from that by the Japanese listeners.

1. Introduction

It has been claimed that Japanese is a mora-timed language in which each mora is composed of a constant duration. A number of researchers have been investigating whether or not each mora possesses a constant duration in terms of production and perception (See the review in [2]). Even though all these researchers have not agreed upon the existence of an absolute constant durational unit, it is generally assumed that a mora in Japanese has unique durational characteristics in comparison with languages which do not belong to mora timing. For example, Sato (1993) [2] has recently argued that a nasal in Japanese is significantly longer if it is placed in the coda in comparison with that in English and Korean, each of which belongs to stress timing. Even in the studies of speech perception, duration plays an important role in the recognition of a moraic nasal [3]. The evidence reported here seems to have suggested that "a sufficient duration" of a nasal in the coda alone is vital in mora timing. It is certainly true that duration plays an important role in the mora hypothesis. The question is how native speakers of Japanese can recognize a nasal as a mora. In the previous findings in production and perception regarding the mora hypothesis duration seems to be the ONLY requirement for the recognition of a mora. However, it is also true that the moraic consonants (N or Q) can only occur in the coda in a syllable. This syllable-based analysis presupposes that as long as these consonants occur in this position, they can be interpreted as a mora. This analysis has nothing to do with duration. These separate analyses for the status

of a mora raise interesting questions. Is a nasal in the coda which does not possess a sufficient duration perceived as a moraic nasal? Is a nasal in the onset which has a sufficient duration perceived as a moraic nasal? This paper will attempt to examine and propose some possible solution for these questions.

2. Experiment I

In Experiment I the duration of a nasal in the onset and the coda was manipulated in such a way that it was reduced to as short as one tenth of the original nasal duration. If a mora is defined only on the basis of duration, the manipulated nasal should not be recognized as a mora.

2.1 Method

2.1.1 Materials

Two groups of three non-words, each of which contains a nasal in the coda and the onset were designed. These are /teNpo, teNto, teNko/ and /tenopo, tenoto, tenoko/. All these words were recorded at a normal tempo by a male native speaker of Tokyo Japanese. In order to avoid the effect of a pitch accent, no accent was assigned. After recording, ten stimuli for each word were made by Kay Sona Graph 5500 in such a way that the duration of a nasal in the onset and the coda was reduced at the rate of one tenth of the original nasal duration. The new stimuli of each word were recorded twice with a two second interval at the random order.

2.1.2 Subjects

Subjects were twelve college students at Dokkyo University, whose major is English.

2.1.3 Procedure

Each subject was instructed in such a way that as soon as he or she heard a word which was repeated twice, write the word in Roman alphabets on a test sheet. If one recognizes a nasal as a moraic one, write it with a capital N. The stimuli were provided to each subject with a binaural headphone in a quiet room.

2.2 Results

The results of the CVN-words and the CVnV-words are shown in Fig. 1. As can be seen, even though the duration of a nasal in the coda and the onset was reduced to as short as one tenth of the original duration, the nasal in the words was recognized as it was.

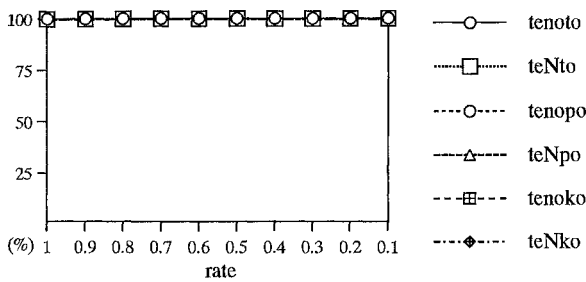


Figure 1. The recognition of the various nasal durations in the coda and the onset.

2.3 Discussion

The reduced duration of a nasal in the two positions, the coda and the onset, were examined in this experiment. Unlike the previous findings, the results in Experiment I have shown that the reduced nasal duration both in the coda and the onset have nothing to do with the recognition of a mora. These results may suggest that the sufficient duration is not the only requirement for the recognition of a mora. This interpretation is correct because Japanese listeners could perceive a nasal in the coda in English as a mora in spite of the fact that the duration is supposed to be significantly shorter than that in Japanese (Cutler and Otake, forthcoming [4]). If the sufficient duration is not the only requirement for the recognition of a mora, what is the decisive factor? The results seem to have suggested that the position where a nasal is placed gives us an important cue. In other words, the recognition of a mora presupposes all the information concerning morae and a syllable structure.

3. Experiment II

In the previous section, it was claimed that as long as a nasal is placed in the coda, "the sufficient duration" is not necessary to recognize a nasal as a mora in speech perception. Does this mean that the duration has nothing to do with the mora hypothesis? If the duration is irrelevant to the properties of a mora, all the findings in the earlier studies must be nullified. In this section, it was examined how the prolonged nasal duration was recognized by Japanese listeners.

3.1 Method

3.1.1 Materials

The same test words in Experiment I were used. These are /teNpo, teNto, teNko/ and /tenopo, tenoto, tenoko/. The words in the second group were read at a normal tempo by the same male native speaker of Tokyo Japanese as did in Experiment I. The nasals in the first group of words were prolonged as long as about 400 ms. in order to obtain sufficient nasal duration. In order to avoid the effect of a pitch accent, no pitch accent was assigned. After recording the words, twenty two stimuli for each word was made by Kay Sona Graph 5500 in such a way that the nasal in CVnV-words was replaced by the one in CVNCV words. The nasal duration in CVnV-words was set as the base duration. Then, the nasal duration in stimulus words was lengthened by 0.1 times longer than the base from 1.5 to 3.5. Between 1.0 to 1.5 and 3.5 to 4.0, there was only one stage. This was done simply because there was no perceptual change between them in the pilot study. The new stimuli of each word were recorded twice with a two second interval at

the random order. The stimuli of each group were recorded in the same tape.

3.1.2 Subjects

Subjects were the same as the ones in Experiment I.

3.1.3 Procedure

The procedure was the same as the one in Experiment I.

3.2 Results

The results in the three synthesized words /tenopo, tenoto, and tenoko/ are shown in Fig. 2. As can be seen in Fig. 2, when the nasal duration in the synthesized word /tenopo/ was 1.5 times longer than the original duration in /tenopo/ (50 ms.), the word was perceived as /tenopo/. In other words, when the duration was lengthened up to 150%, it was still recognized as /tenopo/. However, when the duration exceeded more than 150%, it was perceived either as /tenopo/ and /teNnopo/. The interesting result was that when it exceeded more than 2.0 times, it was always perceived as /teNnopo/. There were some subjects who perceived as /teNopo/, but it was very rare. In short, the Japanese subjects perceived the CVnV-word either as /tenopo/ or /teNnopo/. The rest of the stimuli have shown the exactly the same categorical pattern. See Fig. 2.

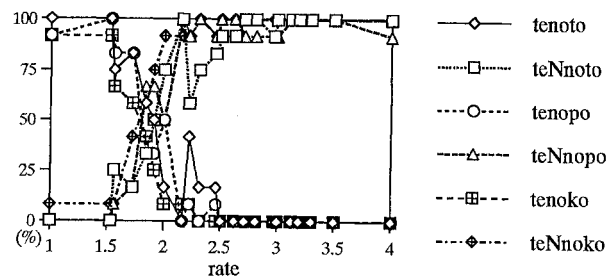


Figure 2. Identification functions for synthetic nasal consonants that differ in duration.

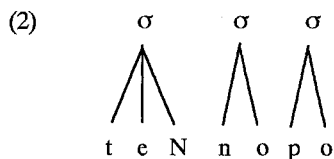
3.3 Discussion

The results in this experiment raise an important theoretical issue.

Unlike Experiment I, it was found that duration plays an important role in the recognition of a moraic nasal in speech perception by Japanese listeners. Look at (1).



As can be seen, /tenopo/ consists of three syllables, where a nasal was placed in the onset of the second syllable. When the nasal duration was within 1.5 times longer than the original duration, (1) was recognized as it was. However, when the duration exceeded 1.5 times longer than the original one, it was recognized as /teNnopo/ in (2).



Now, this phenomenon is very interesting because when the nasal duration in the second syllable was lengthened over a certain point, say, 1.5 times, the nasal was split into the two parts, one for the coda in the preceding syllable and the other for the onset in the following syllable (Fujisaki and Sugito (1977) [3] have also reported a similar figure). In fact, the nasal in the coda in the preceding syllable was recognized as a moraic nasal. The question is where did a nasal in the coda of the first syllable come from? When the nasal duration in the onset was lengthened gradually, it was perceived from /tenopo/ to /teNnopo/. If the nasal did not have important properties regarding the duration, it would not have been observed as a moraic nasal in (2). This phenomenon can be understood only if we assume that duration in Japanese have important properties.

The results in Experiment I have suggested that a moraic status was determined mainly by the position in a syllable and the duration seemed to have nothing to do with it, while the results in Experiment II have suggested that the position of a nasal was determined by the duration of a nasal. The recognition process which was observed in Experiment II can be illustrated as (3). In (3) n' indicates a variable of a nasal whose duration was manipulated in such a way that it was lengthened up to 4 times as long as the original duration.

- (3) n' < a nasal whose duration is 1.5 times longer than the original nasal ---> [n]
 n' > a nasal whose duration is 1.5 times longer than the original nasal ---> [n + n]

If the duration n' was below 1.5 times longer than the original one, it was simply perceived as the onset in the second syllable. On the other hand, if the duration n' was over 1.5 times longer than the original one, it was perceived as [n + n], where the first nasal was assigned as the coda in the preceding syllable. This assignment led us to perceive the nasal as a moraic one.

4. Experiment III

In the previous section, we have examined the relationship between the duration of a moraic nasal and a syllable structure. We have argued that the property of a mora has something to do with duration and also a syllable structure plays an important role in the recognition of a mora. Now, the next question is to find out whether these properties DO belong to native speakers of Japanese, not to non-native speakers of Japanese. In this section, it was examined how Dutch listeners who do not know Japanese perceive the Japanese materials examined in section 3.

4.1 Method

4.1.1 Materials

The materials were the same as the ones in Experiment II.

4.1.2 Subjects

Subjects were twelve college students who do not know Japanese at University of Nijmegen in the Netherlands.

4.1.3 Procedure

Since the Dutch subjects did not know Japanese, they were not expected to distinguish between a moraic nasal and a nasal in the onset. Thus, the subjects were asked to choose what they heard instead. They were instructed to choose one of the six possible choices for the three types of words. Otherwise the procedure was the same as the one in Experiment II.

4.2 Results

The results in the three synthesized words /tenopo, tenoto and tenoko/ perceived by Dutch listeners are shown in Fig. 3. As can be seen, unlike Experiment II, no categorical perception was observed among the Dutch listeners for the three test words.

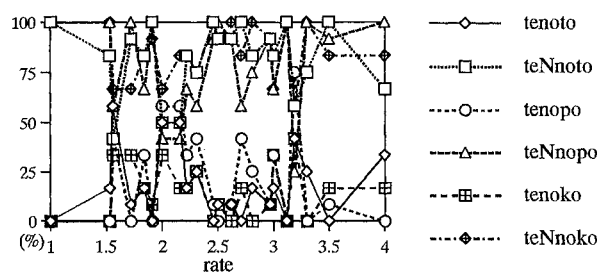


Figure 3. Identification functions for synthetic nasal consonants that differ in duration.

4.3 Discussion

In this section we have examined whether the Dutch listeners who are not supposed to possess mora timing can perceive the Japanese materials in the same way as the Japanese listeners did. The results have clearly shown that the Dutch listeners have never used the same listening process as the Japanese did. These results have suggested that the Japanese listeners are sensitive enough to the duration of a nasal, while the Dutch listeners are not. Because of this different strategy, the results have suggested that the Dutch listeners do not possess a perceptual mechanism which is based upon duration and a syllable structure.

5. General Discussion

The experiments in this study have clearly shown that two factors must be considered during off-line speech perception in order to be able to give a moraic status to a nasal, as we have argued. These are properties of duration and a syllable structure. We will propose a perceptual model on the basis of these two factors below.

Cutler and Norris (1988)[5] have argued that a stress bears an important cue to segment English speech. In their analysis they have claimed that the information on stress plays an important role to determine a syllable boundary. Following their analysis, we would like to propose a similar mechanism, although stress has nothing to do with Japanese. In Japanese, as Otake et al. (1993)[1]

have claimed, a mora is a segmentation unit. However, a mora by itself cannot be determined either by the duration and/or by the position in a given syllable. What this means is that both a syllable structure and duration must be incorporated into a model to give a status of a mora. Here we need what we call "a perceptual window" consisting of a CVC syllable and "a time computing device" which is represented as (3) in section 3.3.

First, let us look at /tenoto/. When the continuous sounds of this word is provided, the perceptual window is applied to the initial CVC syllable in the word as in (4) (Here μ indicates a mora). At this stage a moraic status can be given to the leftmost CV segment, namely, /te/, after recognizing the following segment as a nasal. Here a listener can detect a nasal, but cannot determine whether it can be moraic or not, because the results in Experiment I have shown that the reduced duration in both the onset and the coda cannot determine the status.

$$(4) \quad [t \ e \ n'] \text{ -----} \rightarrow \begin{matrix} [t \ e \ n'] \\ \mu \end{matrix}$$

After assigning the first mora, the perceptual window moves to the adjacent CVC syllable starting with the coda in the preceding syllable. At this stage, the nasal can belong to both the preceding and the following syllables. Now, we must decide where this nasal belongs. In the second window, /n'o/ can stand as the leftmost CV segment, so that the moraic status is given to it, after recognizing the segment /t/, which is illustrated in (5).

$$(5) \quad \begin{matrix} [t \ e \ n'] \\ \mu \end{matrix} [n' \ o \ t] \text{ -----} \rightarrow \begin{matrix} [t \ e] [n' \ o \ t] \\ \mu \quad \mu \end{matrix}$$

Then, as soon as this decision is made, the time computing device must be activated in order to calculate the duration of n'. Since the rate is below 1.5, it is recognized as the onset [n]. This is illustrated in (6).

$$(6) \quad \begin{matrix} [t \ e] [n' \ o \ t] \\ \mu \quad \mu \end{matrix} \text{ -----} \rightarrow \begin{matrix} [t \ e] [n \ o \ t] \\ \mu \quad \mu \end{matrix}$$

Now, let us look at /teNoto/. The first stage of the process is the same as the one in (4). At the next stage, although the perceptual window tries to move from left to right to find another CVC syllable, because of the existence of an impermissible consonant cluster in the Japanese syllable structure, the window cannot move. This is illustrated in (7).

$$(7) \quad \begin{matrix} [t \ e \ n'] \\ \mu \end{matrix} [n' \ t]$$

Here, the nasal cannot find its own seat in the following syllable, so that the nasal is expelled from this syllable to the preceding syllable. Since the nasal in the coda position gives a moraic status, it is recognized as a moraic nasal [N]. This is given in (8).

$$(8) \quad n \ [t \ \text{-----} \rightarrow \begin{matrix} N] [t \\ \mu \end{matrix}$$

Finally, let us look at /teNnoto/. The process at the first and second stages are the same as the ones in (4) and (5), respectively. After these processes, the time computing device must be activated in order to calculate the duration of n'. Since the rate is over 1.5, the nasal is split into two segments, each of which is recognized as the coda and the onset, which is illustrated in (9).

$$(9) \quad \begin{matrix} [t \ e \ n'] \\ \mu \end{matrix} [n' \ o \ t] \text{ -----} \rightarrow \begin{matrix} [t \ e \ n] [n \ o \ t] \\ \mu \quad \mu \end{matrix}$$

Since the nasal in the coda position gives a moraic status, it is recognized as a moraic nasal [N] as in (10).

$$(10) \quad \begin{matrix} [t \ e \ n] [n \ o \ t] \\ \mu \quad \mu \end{matrix} \text{ -----} \rightarrow \begin{matrix} [t \ e \ N] [n \ o \ t] \\ \mu \quad \mu \quad \mu \end{matrix}$$

As we have discussed above, in order to be able to recognize a nasal as a moraic one, the durational-basis model which is often discussed in the studies of production is not sufficient. In addition to it, the information on a syllable structure is indispensable (In fact, a study of a geminate consonant also supports for it [6]).

6. Conclusion

In this paper we have conducted three experiments in order to investigate (1) the durational properties of a mora and (2) the role of a syllable structure in reference to a mora in Japanese during the off-line speech. We have claimed duration and a syllable structure must play an important role for the perception of a mora in Japanese. Although these findings have led us to conclude that most of the syllables containing a nasal can be explained, we have not yet found out why a word like /kaNami/ can be distinguished from /kanami/. We will investigate it in further studies.

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