Nasals and Anticipatory Velar Opening in Osaka Japanese

Mechtild Tronnier, Lund University, Sweden

Introduction

The recognition of a nasal in Japanese as being moraic (i.e. syllable final) or non-moraic (i.e. syllable initial) is said to be based on its duration (see Otake & Yoneyama, 1994). Japanese is often referred to as a mora-timed language, where the mora has unique durational characteristics, although no absolute duration for the mora can be affirmed. In the case of the mora nasal it has been shown to have a longer duration than a non-moraic nasal and cross-linguistically proved to be longer than a syllable final nasal in English or Korean (Sato, 1993).

Otake & Yoneyama (1994) present an investigation on Standard Japanese, which shows that when the mora nasal and the non-moraic nasal have the same place of articulation, their respective duration is the factor that helps the listener to identify the category. However, the authors can not explain why a mora nasal embedded in purely vocalic context (VNV) can be distinguished from a non-moraic nasal (VC[+nas]V).

In intervocalic position, the mora nasal is expected to be realised as a nasal vowel (Vance, 1986). Studies have shown (Tronnier, 1996), that this is not exclusively the case for the Osaka dialect, where a complete oral closure can be observed when an open vowel follows the mora nasal. Furthermore, in the Osaka variety of Japanese the mora nasal differs in its phonological role from its role in standard Japanese in that it can carry pitch accent (see e.g. Nagano-Madsen, 1992).

One of the problems one encounters when analysing the mora nasal spectrographically, is the difficulty separating it from the preceding vowel when it is itself realised as a nasal vowel. It is therefore not possible to measure the duration of the nasal. This also underlines that the duration of a nasal as an almost discrete part of the speech signal cannot be the only cue for the particular nasal category.

In a classic study on coarticulation, Kozhevnikov & Chistovich (1965) claim that in Russian progressive coarticulation of lip protrusion of a rounded vowel does not start earlier than the onset of that syllabic unit. For Japanese, the strong claim has been made that coarticulation does not exceed the moraic unit. In a milder version and within a syllable framework (see Nagano-Madsen, 1992), one could ask whether nasals with different mora status exhibit a different pattern of coarticulation. The mora nasal would then be expected to show an earlier onset of anticipatory velar opening than the non-moraic nasal.

The hypothesis for this investigation is that anticipatory nasalisation is realised differently for the two types of nasals. Thus information about nasality in the preceding vowel could be a factor for identifying the category of the nasal.

In this study the onset of the velar opening anticipating the nasals of the two categories is investigated in Osaka Japanese.

Experimental Procedure

Material, Subjects and Recordings

The recorded material consists of read speech, presented in Japanese writing. It contains one list of sentences of the type "*A* yori wa, *B* hoo ga ii" and a second list where the items *A* and *B* are reversed: "*B* yori wa, *A* hoo ga ii", where *A* is the target word and *B* some other word, which stands in semantic relation to *A*. The target word thus appeared both initially and medially, and contained either the mora nasal or the non-moraic nasal in intervocalic position. The pre-nasal vowel was part of the first mora of the word. Thus two categories of target words were at hand: (a) VC[+nas]V-words, where C[+nas] is a non-moraic nasal, being the onset of the second mora in the target word and (b) VNV-words, with the mora nasal in syllable final position in the first syllable of the target word, where it constitutes the second mora of the target word. For the second category, a morpheme boundary occurred between the mora nasal and the following vowel. For the first category, a morpheme boundary sometimes occurred

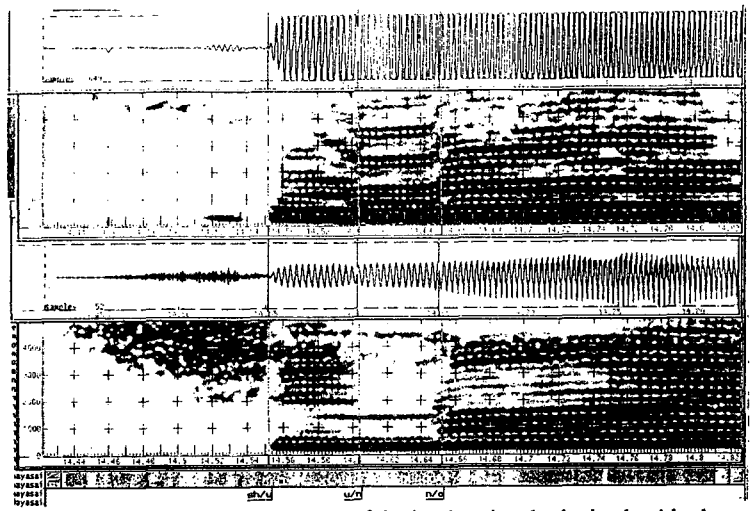

Figure 1. Waveforms and spectrogram of both, the signal obtained with the accelerometer microphone attached to the nose (above) and the regular speech signal, followed by the phonetic labels of the word *shuno* (in IPA [ʃɯno]). Here, pattern 1 is presented, which shows full formant structure from the beginning of the vowel.

at the syllable boundary before the nasal. There were 61 type (a) words and 64 type (b) words. The grand total for both sentence positions was thus 250 items. However, due to speech errors, misreadings, hesitations etc., the number obtained was somewhat smaller. In addition, the full combination of all five Japanese vowels in both pre and post nasal position (25 pairs) was not available. The remainder of the sentence, including word *B*, did not to contain any other phonological nasal. The speakers were asked to read the sentences without interruptions.

The recordings were made on a two channel DAT-recorder, where the speech signal was recorded on one channel and the nasal resonance was recorded on the other. The latter was done by attaching a lightweight accelerometer microphone (*Hot Spot* by *K & K Sound Systems)* to the upper part of the speaker's nose, where the lateral nasal cartilage can be found. This position has been found most suitable for obtaining a good nasal signal (Lippmann, 1981).

The group of subjects consisted of three native speakers of Kansai Japanese. They have all lived in the city of Osaka all their lives and their parents are natives of the city or the Kansai area. The recordings were made in the speakers' homes.

Acoustic Analysis

The recorded material was analysed with ESPS/Waves+. Judgements on the opening of the velar port were made from waveforms and spectrograms with the nasal and the oral channels aligned. The presence of visible spectral energy in the spectrogram of the nasal channel across the whole spectrum of 8kHz from the beginning of the pre-nasal vowel was deemed to reflect the lowering of the velum prior to the vowel onset. A sudden increase of visible spectral energy during two or three periods of the speech signal, was interpreted as a swift wide opening of the velar port (Figure 1). A more gradual increase of spectral energy was taken to reflect a gradual lowering of the velum (Figure 2).

Observed Velar Opening Patterns

The recorded data presented us with more than the two hypothesised velar opening patterns. Instead, six different patterns could be extracted, which are described in detail below.

Pattern 1: Full nasal spectral energy is observed either right from the beginning of the pre-nasal vowel or at least within the first three periods of the speech signal, which mirrors velar opening either prior to the vowel onset or rapid velar lowering simultaneously with the vowel onset and results in a fully nasalised vowel (Figure 1). This pattern was hypothesised for the velar opening procedure of the mora nasal.

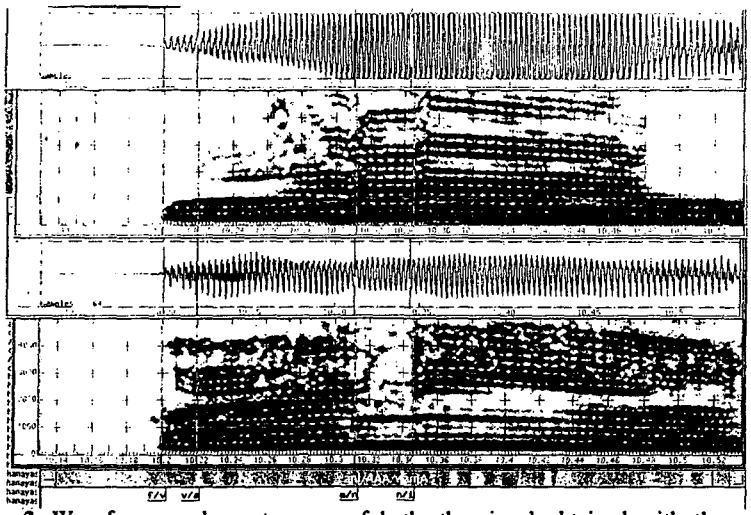

Figure 2. Waveforms and spectrogram of both, the signal obtained with the accelerometer microphone attached to the nose (above) and the regular speech signal, followed by the phonetic labels of the Japanese word *wani* (in IPA [fvani]). Here, pattern 3 is presented, showing increasing formant structure from the beginning of the vowel.

Pattern 2: A sudden appearance of full spectral energy later in the pre-nasal vowel or at the onset of the nasal, which mirrors a rapid velar opening closer to the beginning of the nasal itself and results in a nasalised off-set of the pre-nasal vowel or a consistently non-nasalised vowel. This pattern was hypothesised for the velar opening procedure of the non-moraic syllable initial nasal.
Pattern 3: Gradually increasing spectral energy from the vowel onset on, which becomes complete either later in the vowel or at the onset of the nasal. This pattern represents gradual velar opening during the pre-nasal vowel and results in a gradual increase of nasalisation of the vowel (Figure 2).
Pattern 4: Gradually increasing spectral energy beginning later in the vowel leading to full spectral energy either later in the vowel or at the onset of the nasal. In this case, gradual velar opening starts late in the pre-nasal vowel and results in a partially non-nasalised and partially nasalised vowel where nasalisation increases gradually .
Pattern 5: Gradually slightly increasing spectral energy from the pre-nasal vowel onset onwards and a sudden appearance of full spectral energy later in the pre-nasal vowel or at the onset of the nasal. Here, a gradual lowering of the velum is followed by a rapid lowering, which results in a partially nasalised vowel where nasalisation increases gradually, and a fully nasalised vowel offset.
Pattern 6: A moderate amount of spectral energy over the whole spectral range from the beginning of the pre-nasal vowel, followed by a sudden appearance of full spectral energy either later during the vowel or at the onset of the nasal. The velum appears to be half-open at the beginning of the pre-nasal vowel. Later in the pre-nasal vowel a complete velar opening is achieved through a rapid velar lowering. A somewhat nasalised portion is followed by a fully nasalised portion of the vowel.

Statistical Analysis

The frequency of occurrence of all patterns was calculated for each of the five vowels and related to both the non-moraic and the mora nasal, to each speaker and to each sentence type. An ANOVA was applied to test for any influence of these factors on the pattern of velar opening.

Results and Discussion

It was hypothesised that two different velar opening patterns would reflect the two nasal categories, such that pattern 1 would represent the syllable final mora nasal and pattern

2 would represent syllable-initial non-moraic nasal. This was not supported. Both patterns occurred for both nasal categories, with pattern **1** being preferred to pattern **2** (see Figure 3). Comparing the two categories, one can observe a more frequent use for pattern **2** in the case of the mora nasal ($p<0.05$, see Table 1), which cantradicts the hypothesis. In addition, four other patterns were seen in the recorded data. The relationship of all six patterns to the nasal categories was therefore investigated.

Pattern	Speaker	(Nasal) Cat	Speaker vs. Cat	Set vs. Cat	Speaker vs. Set vs. Cat
1	0.0499	0.2336	0.1045	0.2157	0.78
2	0.0031	0.017	0.0798	0.3325	0.406
3	0.0487	0.7256	0.1842	0.7265	0.8051
4	0.0000	0.3368	0.4218	0.8738	0.8361
5	0.2010	0.1276	0.8331	0.587	0.6503
6	0.0012	0.9223	0.879	0.2301	0.879

Table 1. P-values for the interaction between each velar opening pattern and all the other factors according to multiple factor ANOVAs.

Pattern **3** occurred most frequently in both nasal categories, with no significant difference between them ($p>0.05$). The other three velar opening patterns **4**, **5** and **6** occurred much less frequently. There was no difference between the two nasal categories for any pattern.

Most of the velar opening patterns varied consistently between the speakers (Table 1, column 2 "Speaker"), except for Pattern **5**, which was not produced by some speakers and only rarely by the others. On the other hand, the velar opening patterns were used for both nasal categories in the same way by all three speakers, reflected in the lack of significance in the use of any velar opening pattern for either nasal categorie (see Table 1, column 4 "Speaker vs. Cat"). Finally, there was no significant influence of the sentence position of the target word on the velar opening pattern for either nasal category (Table 1, column 5 "Set vs. Cat"). This also holds across the three speakers (Table 1, column 6 "Speaker vs. Set vs. Cat").

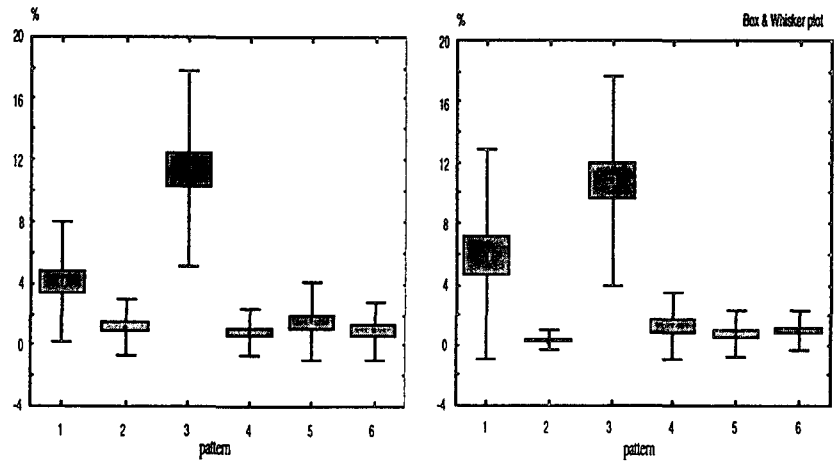

Figure 3. The frequency distributions (in %, vertically) of the different velar opening patterns (horizontally) for the two nasal categories, the mora nasal (left) and the non-moraic nasal (right), across all speakers and for both sentence positions.

In summary, both nasal categories were rendered by the same velar opening patterns, pattern **3** being the the most frequent pattern followed by pattern **1**. The other patterns are less frequently produced, although pattern **2** was significantly more often associated

with the mora nasal. This holds across the three speakers and despite the occurrence of the target words in different sentence positions.

Conclusions

It has been shown that the production of a nasal in Osaka Japanese as being moraic or non-moraic is not achieved by consistent variation of the anticipatory velar opening pattern in the vowel preceding the nasal. Both two hypothesised opening patterns occur with both nasal categories. Furthermore, pattern **2**, which was hypothesised to occur with the non-moraic nasal, ocurred more frequently with the mora nasal. This pattern was however one of the less frequent ones. Pattern **1**, which was hypothesised to occur with the mora nasal occured equally frequently with the non-moraic nasal. Pattern **1** appeared to be one of the more frequent patterns. In addition to the hypothesised patterns, four more unexpected velar opening patterns were found. One of them (pattern **3**) is the most preferred pattern for both nasal categories. The common feature of the two frequent patterns (pattern **1** and **3**) was that the velar port was opened right at the beginning of the preceding vowel. But they progress differently during the vowel.
The explanation that two nasal categories in Japanese are differentiated in intervocalic position by consistent variation of nasalisation onset procedures in the previous vowel was not supported for the Osaka dialect. Other factors have to be taken into consideration to explain the identification ability observed for Standard Japanese by Otake and Yoneyama. The present data suggest other possible cues such as devoicing or reduction of the vowel preceding the non-moraic nasal. Those effects do not seem to appear in the case of the mora nasal. However, such effects need to be investigated in further detail.

Acknowledgement

This work was supported by the Scandinavian-Japan Sasakawa Foundation. I would like to thank my subjects for their patience and co-operation when reading the extensive material.

References

Kozhevnikov, V.A. & Chistovich, L.A. 1965. *Speech: Articulation and Perception.* Washington: Joint Publications Research Service.

Lippmann, R.F. 1981. Detecting nasalisation using a low cost accelerometer. *J.Speech and Hear. Res.* 24, pp. 314-317.

Nagano-Madsen, Y. 1992. *Mora and Prosodic Coordination.* Lund: Lund University Press.

Otake, T. & Yoneyama, K. 1994. A Moraic Nasal and a Syllable Structure in Japanese. *Proceeding of the ICSLP 94, Yokohama,* pp. 1427-1430.

Sato, Y. 1993. The Duration of Syllable-Final Nasals and the Mora Hypothesis in Japanese. *Phonetica* 50, pp. 44-67.

Tronnier, M. 1996. Contextual Aspects as a Factor in Variation in the Phonetic Realisation of the Mora Nasal in Osaka Japanese. *Proceedings of the 1st ESCA Tutorial and Research Workshop on Speech Production Modeling* and *the 4th Speech Production Seminar, Autrans,* pp. 5-8.

Vance, T.J. 1987. *An Introduction to Japanese Phonology.* Albany: State University Press.