PRODUCTION OF THE JAPANESE MORAIC NASAL /N/ BY SPEAKERS OF ENGLISH: AN ULTRASOUND STUDY

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ABSTRACT

For native speakers of English learning Japanese, the moraic nasal is a foreign sound as its uvular place is unmatched by the /m/, /n/, or /ŋ/ found in English. The articulations of /N/ by three native speakers of English, whose proficiency levels were reported as basic, intermediate, and advanced, were investigated using ultrasound. All three participants used an alveolar gesture similar to their English /n/ for the utterance final /N/. In /NC/ contexts, regressive place assimilation was observed, but, unlike L1 Japanese speakers, L2 speakers preserved the alveolar gesture when the nasal assimilated to a following labial or velar consonant. This suggests that the assimilation process differs between languages: L1 speakers lacked place specification for N in NC, while L2 speakers continued to use alveolar place during an extended closure for the second C.

Keywords: Japanese moraic nasal, L2 production, ultrasound, assimilation.

1. INTRODUCTION

An utterance final Japanese moraic nasal /N/ is commonly transcribed as a uvular nasal, e.g. [7], but recent articulatory studies have revealed its variability among speakers [6, 10, 11, 16], ranging from the alveolar ridge to the uvula. The place is, however, consistent within each speaker.

In case of /N/ followed by a phoneme, regressive place assimilation has been observed [14] and the numbers of its allophones are reportedly nine [14] to 80 [8] depending on the combination of the preceding and following phonemes. It is generally regarded that the assimilation of Japanese /N/ is obligatory [5]. The assimilation strategy is not fully understood, but categorical assimilation was reported in a few studies [4, 10, 12].

For native speakers of English learning Japanese, the moraic nasal is a foreign sound as there is no uvular nasal (or any nasal sound distinguished from /m/, /n/, or /ŋ/) in English. Therefore, an L1 effect might be seen when native speakers of English produce a Japanese moraic nasal. As a result, it is speculated that the moraic nasal is most likely to be replaced by an alveolar nasal because it is written as "n" in Roman alphabet utilized for learners who do not learn the Japanese writing system from the onset.

If that is the case, the more advanced learners depend more on their perception of native speaker's utterance of /N/ corresponding to the character "ん". Consequently, the learners should be able to differentiate the L2 phoneme from their L1 /n/.

It is also possible that the /N/ is perceptually more similar to /ŋ/ than /n/ and that /ŋ/ will be used instead. Learning the Japanese orthography might reinforce this tendency too. However, in terms of frequency of occurrence, /n/ is more frequent than /ŋ/ and may therefore be preferred on that basis. Testing the perception of /N/ as in PAM-L2 (the Perceptual Assimilation Model-L2 [2]) might help explain production results as well.

Another question to be discussed is how an assimilation pattern of the Japanese moraic nasal is realized by L1 English speakers. English syllable-final nasal place assimilation is a well-known phenomenon and articulatory studies have provided evidence of its gradual process; especially when alveolar stop consonant assimilated to the following consonant at the word boundary, the residual alveolar gesture was observed [1]. Assuming that this L1 English assimilation pattern transfers to L2 Japanese and that L1 English speakers use /n/ for /N/, an alveolar gesture may be seen in /N/ produced before a stop consonant as resulting from gestural overlap.

Few articulatory studies have been conducted on production of the Japanese moraic nasal by L2 speakers, and very little is known about the assimilation in L2 contexts. Thus, this paper examines the articulation of the Japanese moraic nasal by native speakers of English to see 1) the place of articulation (PoA) in the utterance-final position; 2) if variability exists as seen in the Japanese speakers depending on their proficiency level; and 3) to see how assimilation occurs in /NC/ contexts.

2. METHODS

2.1. Data collection

The experiment took place in the Speech Production, Acoustics and Perception Laboratory at the Graduate Center, the City University of New York (CUNY).

Six native speakers of American English participated in the experiment. Two speakers who were reportedly regularly exposed to a language other than English as a child, and one speaker who had lived in China and learned Chinese for five years were excluded from the analysis to avoid any influences of the languages. As a result, three speakers (1 female, EF03, who was from New York, 1 female, EF04, who was from Florida, and, 1 male, EM03, who was from Louisiana) were included for analysis. Their proficiency level of Japanese was reported as intermediate, advanced, and basic respectively. The intermediate speaker received N4 and the advanced speaker, N2 in Japanese-Language Proficiency Test, where N5 is the easiest and N1 is the most difficult.

The participants were recruited by the author via an e-mail advertisement, approved by the CUNY IRB, and they were compensated for their participation in the study. The participants ranged in age from 20 to 40, had no history of neurological or speech/hearing impairment, and had corrected-to-normal vision. Language background information about the participants was collected by means of a questionnaire.

Participants read aloud ten repetitions of seven target words with a moraic nasal (words containing /aNCa/, /aNa/, /aNaN/, or /ɯN/) and six control words without a moraic nasal (words containing /aCa/ or /aa/). Among these recorded words, /kaNaN/ ([kaɰ̃aɴ] かんあん 'consideration') was used for analysis of the utterance-final /N/. For the word-medial /N/, /aNba/ ([amba] あんば 'pommel horse') and /aNga/ ([aŋga] あんが 'lay down') were used. As controls representing a consonant without /N/, /abata/ ([abata] あばた 'pockmark') and /hagata/ ([hagata] はがた 'teeth mark') were used.

The participants also produced ten repetitions of eleven English target words with a nasal, containing /ʌnCə/, /ʌnnæ/, /ʌnə/, /ʌn/, /ʌm/, /ʌŋ/, /un/, or /um/, and six control words without a nasal, containing /ʌCə/ or containing the vowel /ɑ/. Among these recorded words, "analysis" was used for an English alveolar nasal reference.

English trials followed the Japanese trials after a short break. Japanese words were shown one at a time in Japanese orthography (hiragana) and English words in English orthography, using Microsoft PowerPoint on a computer screen positioned approximately one meter in front of the participants.

The audio signal, ultrasound video, and motion measurement data were recorded simultaneously.

The audio signal was digitally recorded monaurally at 44,100 Hz, 16-bit resolution, using a directional Sennheiser microphone on a microphone stand positioned approximately 15 centimeters from the participant's lips.

Real-time mid-sagittal images of the oral cavity were recorded with an ultrasound system (Ultrasonix; SonixTouch) using 2D imaging (B-mode) at a frame rate of 59.9 frames per second. The tongue images were recorded while speakers uttered the stimuli and the palate images were recorded while they swallowed water.

The Haskins Optically Corrected Ultrasound System (HOCUS) [15] was used to adjust positions in the ultrasound images by tracking the head movement with an optoelectronic motion measurement system (Optotrak Certus Motion Capture System: NDI).

The lip movement data was also collected using the Optotrak. Infrared emitting diodes (IREDs) were attached to each participant's lips, one immediately above the upper lip and one below the lower lip along the midsagittal line.

2.2. Analysis

The midpoint of each target segment from the audio recording was measured by visual detection of the changes in formant values and periodic patterns in the waveform using Praat software [3].

The tongue and palate edge contours were hand-measured by selecting 16 points via GetContours [13] and interpolated to 100 points on an xy-coordinate for each frame. The extracted tongue and palate contours were computationally aligned in a head coordinate space for each participant by HOCUS [15].

After the HOCUS correction, the tongue contours were averaged over repetitions for each stimulus by speaker. Specifically, the y-values were averaged along each x-value (along a perpendicular line), which enables calculation of tongue height at the given horizontal locations within the oral space.

The PoA for each speaker was determined using constriction location (CL), which is the horizontal location (x-value) of the point on the tongue closest to the palate, and constriction degree (CD), which is the Euclidean distance between the palate and tongue at CL.

The averaged tongue contours were plotted showing CL and CD and with error bars showing 95% confidence intervals.

Lip aperture (LA) was also calculated as the Euclidean distance between the upper and lower lips. The lip IREDs came off for one male speaker during the experiment, and that speaker was excluded from the lip analysis.

Statistical analyses relating to individual variabilities of PoA and assimilation strategy were not included due to the small sample size.

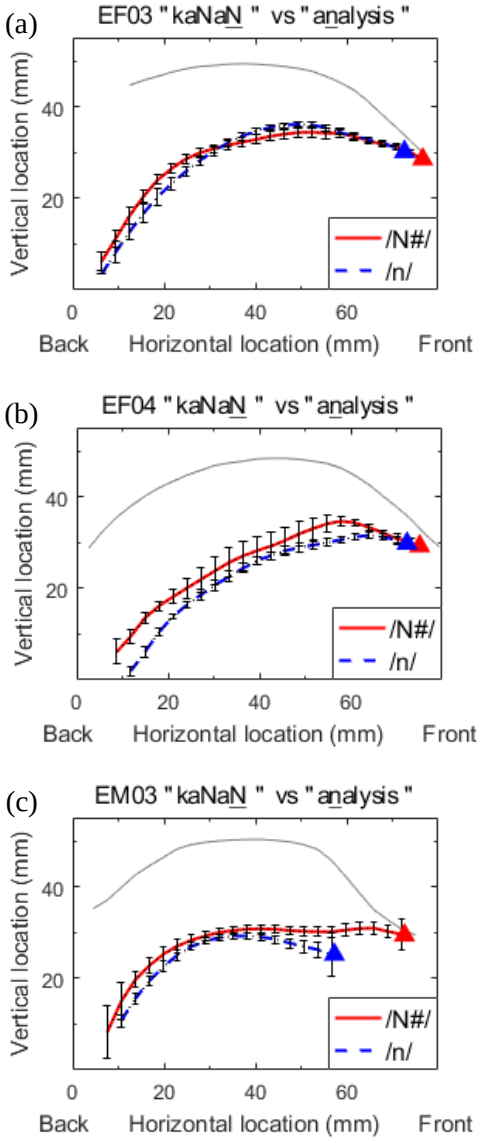
3. RESULTS

For all the figures, error bars show the 95% confidence interval. A gray line above the tongue contours show the averaged palate contour. Triangles show the constriction location (the closest point to the palate) of the averaged contour.

3.1. Utterance-final /N/

All three speakers used an alveolar gesture for the utterance final Japanese moraic nasal /N/ (Fig. 1).

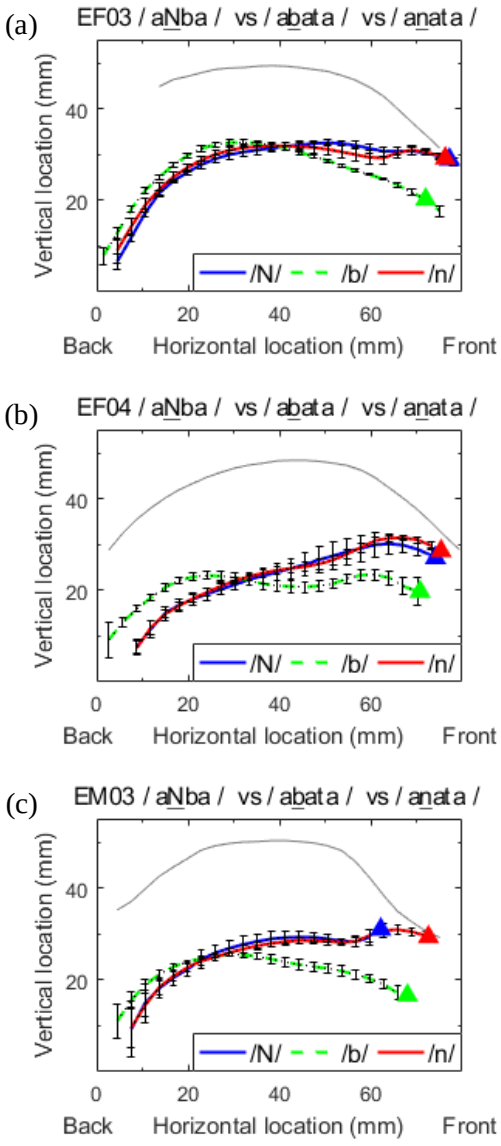
Figure 1: Averaged tongue contours in speaker EF03 (a), EF04 (b), and EM03 (c) for /N#/ in /kaNaN/ compared with that for /n/ in "analysis."



3.2. Word-medial /N/

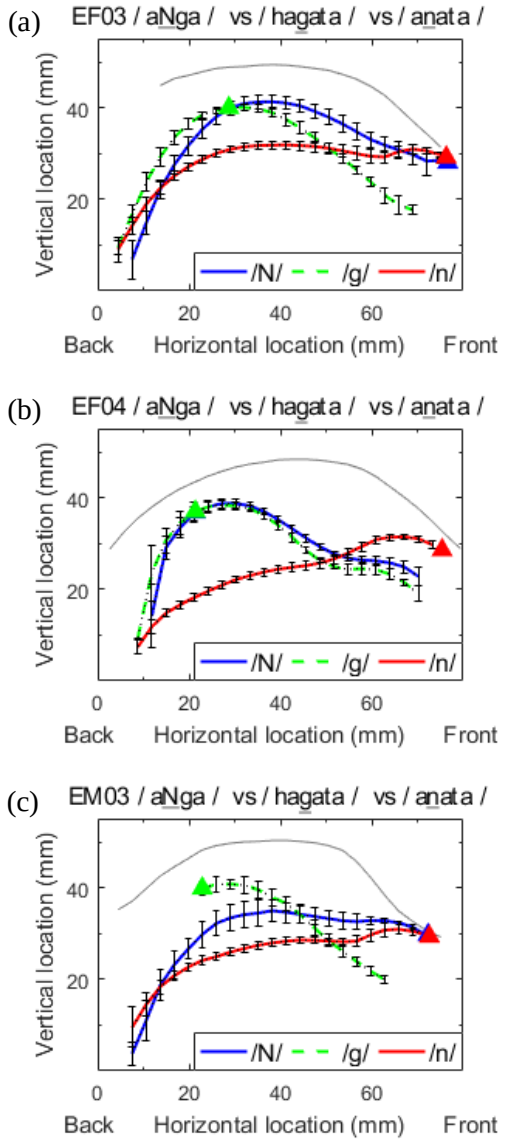
As seen in Fig. 2, all the speakers used an alveolar gesture for /N/ in /Nb/ context. Lip analysis for EF03 and EF04 revealed that the LAs for /N/ in /Nb/ were narrower than those for /b/ in /abata/. It has been reported that the lower lip tended to reach a higher vertical position for long consonants (/pp/ or /mm/) than for short consonants (/p/ or /m/) [9]. If the labial gesture for /N/ in /Nb/ ([mb]) was blended with that for the following /b/, it is hypothesized that a longer constriction for /Nb/ resulted in a higher lower lip position and a smaller Euclidean distance (although the point of closure is not apparent in this measure). These lip gestures suggest that /N/ assimilated to the following /b/ for these two speakers.

Figure 2: Averaged tongue contours in speaker EF03 (a), EF04 (b), and EM03 (c) for /N/ in /aNba/ compared with those for /b/ in /abata/ and /n/ in /anata/.



As seen in Fig. 3, EF03 and EM03 made an alveolar constriction for /N/ in /Ng/ context although the tongue body was higher than in the control /n/. EF04 used a tongue shape similar to /g/.

Figure 3: Averaged tongue contours in speaker EF03 (a), EF04 (b), and EM03 (c) for /N/ in /aNga/ compared with those for /g/ in /hagata/ and /n/ in /anata/.



3. DISCUSSION

The articulation of Japanese moraic nasal /N/ by native speakers of English was examined by ultrasound. All three speakers analyzed in this study used an alveolar gesture for utterance-final /N/, regardless of their proficiency levels. Individual variability for /N/, from alveolar to uvular, seen in native speakers of Japanese [6, 10, 11, 16] was not observed. As there is no uvular nasal in English, it is speculated that English speakers may be unable to use it and choose a similar sound which is in their L1 phoneme inventory. One of the possible reasons why /n/ is chosen among the other variations is that when /N/ is written in the Roman alphabet instead of Japanese orthography, "n" is used such as /hoN/ ('book') represented as "hon" in the Roman alphabet. On the other hand, some L1 Japanese speakers use an alveolar place as well [10, 11].

However, there was no effect of proficiency, despite its being expected as learners get used to the Japanese writing system as well as having more experience with native variants. This suggests that /N/ might have been categorized as L1 /n/ in the learners' phonemic category and a new category for L2 /N/ might not have been established even when they had become advanced.

If the English speakers categorize Japanese /N/ into their L1 /n/, it is predicted that /N/ assimilates to /n/ in perception, adopting PAM-L2 [2]. But at the same time, it is also possible that it assimilates to /m/ or /ŋ/, which are also the allophones of /N/. Then, asymmetric results could be observed between production and perception, i.e., using /n/ for /N/ in production but /N/ assimilates to /m/ or /ŋ/ in perception, due to the acoustic and/or articulatory similarity.

In /Nb/ contexts, all the speakers used an alveolar gesture, and the two speakers who had lip data made a lip constriction. This suggests that /N/ was co-produced with the following /b/ (at least for the two speakers for whom there was lip data), because the alveolar gesture was retained for all the speakers.

In /Ng/ contexts, speaker (EF03) used a combined alveolar and velar gesture; one (EM03) used an alveolar gesture with a partial velar gesture, and one speaker (EF04) used a velar gesture. The first two speakers thus appear to have combined articulation for two L1 categories (/n/ and /ŋ/), resulting in partial assimilation to the velar context. For the speaker who did not use an alveolar gesture, /N/ completely assimilated to the following /g/, as was typical for L1 Japanese speakers [10]. This speaker is the one with advanced L2 competence, so she might have realized the variations of /N/ produced by native speakers of Japanese and applied the realization for a certain context, whereas the basic and intermediate speakers might not, and they apply their L1 assimilation strategy to all the L2 contexts.

In conclusion, this study revealed that L1 English speakers preferred an alveolar nasal for Japanese moraic nasal /N/, which is reportedly more variable among Japanese speakers. For assimilation, gestural overlap resulted from partial assimilation was observed for all the three speakers in /Nb/ or /Ng/ contexts as opposed to the categorical assimilation seen in Japanese speakers. Further investigation will be necessary with more participants to draw more decisive conclusions.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

[1] Barry, M. C. 1985. A palatographic study of connected speech processes. *Cambridge Pap. phonetics Exp. Linguist.*, 4, 1–16.

[2] Best, C. T., Tyler, M. D. 2007. Nonnative and second-language speech perception: Commonalities and complementarities. *Language experience in second language speech learning: In honor of James Emil Flege*, 1334, 1–47.

[3] Boersma, P., Weenink, D. 2016. Praat: Doing phonetics by computer. Version 5.3.51, retrieved September 2016 from http://www.praat.org/.

[4] Colantoni, L., Kochetov, A., Steele, J. 2016. L1 influence on L2 assimilation: An EPG study of English /n/+stop sequences. *Paper presented at the LabPhon 15*, Cornell University, Ithaca, NY.

[5] Cutler, A., Otake, T. 1998. Assimilation of place in Japanese and Dutch. *The Fifth International Conference on Spoken Language Processing*, 1751–1754.

[6] Hashi, M., Kodama, A., Miura, T., Daimon, S., Takakura, Y., Hayashi, R. 2014. Articulatory Variability in Word-Final Japanese Moraic-Nasals : An X-ray Microbeam Study (<Feature Articles> Articulatory Phonetics: Focus on Japanese). *J. Phonetic Soc. Japan*, 18, 2, 95–105.

[7] International Phonetic Association. 1999. *Handbook of the International Phonetic Association : a guide to the use of the International Phonetic Alphabet*. Cambridge, U.K. ; New York, NY: Cambridge University Press.

[8] Kokuritsu Kokugo Kenkyūjo [National Institute for Japanese Language and Linguistics]. 1990. *Nihongo no boin, shiin, onsetsu : chōon undō no jikken onseigakuteki kenkyū [Vowels, consonants and syllables in Japanese: experimental phonetics study in articulatory movements]*. Tokyo: Shūei Shuppan.

[9] Löfqvist, A. 2005. Lip kinematics in long and short stop and fricative consonants. *J. Acoust. Soc. Am.* 117(2), 858–878.

[10] Mizoguchi, A. 2019. *Articulation of the Japanese Moraic Nasal: Place of Articulation, Assimilation, and L2 Transfer*. (Unpublished doctoral dissertation). The Graduate Center of the City University of New York.

[11] Mizoguchi, A., Roon, K., and Whalen, D. H. 2016. Ultrasound evidence for place of articulation and assimilation behaviors of the Japanese moraic nasal /N/. *J. Acoust. Soc. Am.*, 140, 4, 3109–3110.

[12] Stephenson, L., and Harrington, J. 2002. Assimilation of place of articulation: Evidence from English and Japanese. *Proceedings of the 9th Australian international conference on speech science and technology*, 592–597.

[13] Tiede, M. K. 2016. GetContours. GitHub repository, https://github.com/mktiede/GetContours.

[14] Vance, T. J. 2008. *The sounds of Japanese*. Cambridge, UK ; New York: Cambridge University Press.

[15] Whalen, D. H., Iskarous, K., Tiede, M. K., Ostry, D. J., Lehnert-LeHouillier, H., Vatikiotis-Bateson, E., Hailey, D. S. 2005. The Haskins optically corrected ultrasound system (HOCUS). *J. Speech Lang. Hear. Res.*, 48, 3, 543–553.

[16] Yamane, N and Gick, B. 2010. Speaker-Specific Place of Articulation: Idiosyncratic Targets for Japanese Coda Nasal. *Can. Acoust.*, 38, 3, 136–137.