Place Assimilation of the Moraic Nasal to /r/ in Japanese

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Background: The Japanese moraic nasal /N/ is known to regressively assimilate to the following plosives in terms of place of articulation (e.g., [1, 2]), as is demonstrated by several articulatory studies (e.g., [3, 4, 5]). /N/ is generally thought to assimilate not only to plosives but also to the liquid consonant /r/ (e.g., [1, 6]). However, the paucity of experimental data observing the actual articulatory behavior limits our understanding of the gradient nature of the process.

We address two aspects of liquids for which the assimilation may not work as in the other coronal consonants. First, the constriction location of Japanese /r/ is known to vary considerably [7], including those that are more posterior than in other coronals (e.g., [7, 8]). Second, in the framework of Articulatory Phonology (AP; [9]), the possibility that liquids are cross-linguistically gesturally complex segments involving the coordination of coronal and dorsal gestures has been explored [10]. Different views exist as to whether this applies to Japanese /r/ as well [8, 11]. In this study, we report the results from an ultrasound study to examine the place assimilation of the Japanese moraic nasal /N/ to /r/ and the extent to which it differs from the assimilation to /d/ and /n/ as well as the utterance-final /N#/.

Methods: The current study reports data from two native speakers of Tokyo area Japanese (one female, AJF01, and one male, AJM01, both in their 20s). We report the articulatory results for the items shown in Table 1. Each word was presented 10 times in a random order and the participants read them aloud in isolation. Audio and ultrasound recordings were obtained simultaneously. For the analysis, the midsagittal tongue contours at the acoustic midpoint of each target consonant were manually traced using GetContours [12].

Results & Discussion: Fig. 1 shows the tongue contours for the target segments in each speaker, predicted from the repetitions with 95% confidence intervals using the generalized additive model (GAM; [13]). Overall, the results confirm the traditional description in which coda nasals assimilate in place to plosives and liquids. An additional finding is that the constrictions for /d/, /n/, and /r/ are more apical, as inferred from the concave shape at the tongue blade, while the constrictions for /N/ in /Nd/, /Nn/, and /Nr/ are more laminal, as indicated by the more convex shape. This may be a result of a gestural planning specific to assimilated nasals through which speakers achieve a prolonged and more stable tongue tip (TT) constriction. Alternatively, this may be explained as gestural blending in the framework of AP. Assuming that there is an underlying tongue body (TB) gesture for /N/, as suggested in [4], the need to raise the TT and TB simultaneously may result in the slight raising of the tongue blade. This is schematized in Figs. 2a and 2b, following the box notation in [9].

The tongue contours for /r/ and /Nr/ suggest that the constriction location of the TT is higher and more posterior than that of the obstruents, especially for AJF01. Furthermore, we observe a slight bulge around the TB area for /r/ and /Nr/ for both speakers. While this may simply be viewed as a by-product of the retracted TT constriction, possibly involving a concentration of the mass due to the contraction of the tongue surface muscles, it is also consistent with the view that the Japanese /r/ is gesturally complex. As shown in Fig. 2c, the bulge in the TB area may be accounted for as the cumulative effect of the intrinsic dorsal gestures of /r/ and /N/.

Conclusion: The current study reported the differences among the tongue contours of /N/ followed by /r/ and the other consonants, /d/ and /n/. Further investigation is needed to test the analyses discussed above and obtain a full picture of the assimilation process. Our results also highlight the need to combine point-tracking techniques such as EMA and whole-tongue imaging techniques such as ultrasound or rtMRI to better understand the nature of the lingual gesture involved in the production of /r/ (i.e., retraction as a horizontal displacement of the tongue body vs. sliding back of the tongue surface).

Table 1 Experimental stimuli (target segments are indicated in red).

/NC/				/C/			
/Nd/	/aNda/	あんだ	'a hit'	/d/	/hadaka/	はだか	'naked'
/Nn/	/aNna/	あんな	'like that'	/n/	/anata/	あなた	'you'
/Nr/	/haNra/	はんら	'half-naked'	/r/	/ara/	あら	'coarseness'
/N#/	/kaNaN/	かんあん	'consideration'	–	–	–	–

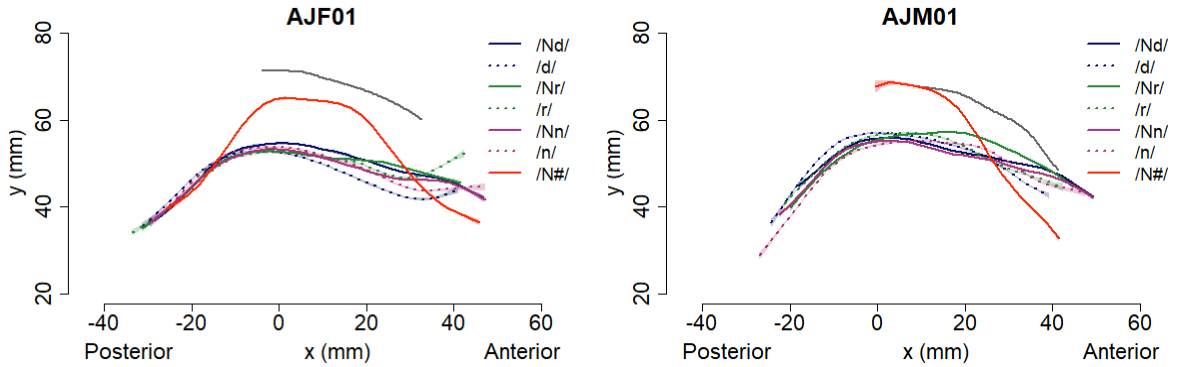

Figure 1 GAM contours with 95% confidence intervals for the seven target segments in each speaker. The gray line above the tongue contours shows the palate contour.

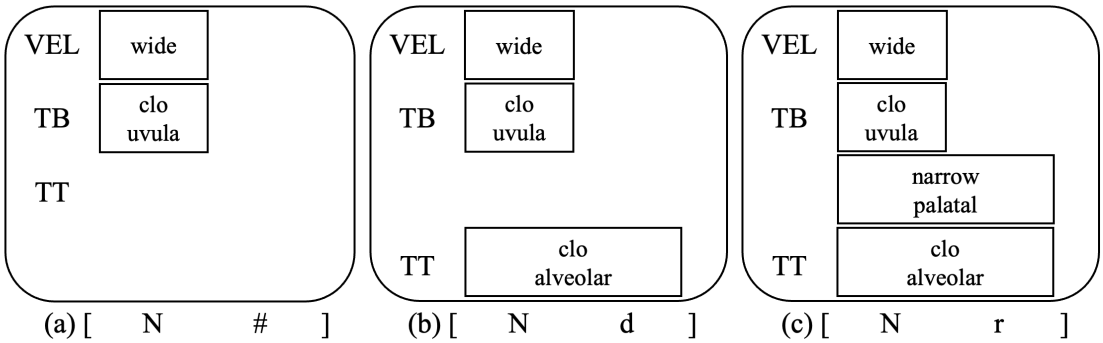

Figure 2 Partial gestural scores showing the activation intervals of consonantal gestures.

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