

Effects of a Formant Transition of Preceding Vowel off-glide on Perception of Japanese Geminate Consonant *Sokuon*

Emi Yanagisawa, Takayuki Arai

Sophia University

emi yana@hotmail.com, arai@sophia.ac.jp

The primary acoustic correlate of a single-geminate distinction in Japanese is a difference in duration — closure duration for stops and frication duration for fricatives (Kawahara, in press). As durational cues, not only absolute duration of a geminate consonant but also relational correlates such as ratio of stop closure to the preceding vowel, following vowel, preceding mora or word are known as cues for single-geminate distinction. Non-durational cues of a single-geminate contrast in Japanese such as F0, intensity and voice quality are also investigated (Idemaru and Guion, 2008). Nakano (1974) indicates that an abrupt damping in intensity of preceding vowel off-glide is associated with a perception of Japanese obstruent geminates “Sokuon”. We assume that the damping is caused by a contact or approximation of the articulator in order to articulate obstruent or fricative consonants and a formant transition ought to be associated with the damping. Yanagisawa and Arai (2013) conducts perception experiment using natural speech and reports that an utterance does not tend to be perceived as Sokuon when an off-glide of preceding vowel does not include formant transition and steep intensity damping. According to Yanagisawa and Arai (2013), the formant transition seems to play one of the roles as a perceptual cue of Sokuon. However, it is not confirmed as yet by any researches. Therefore, the present study tested the effects of formant transition of preceding vowel on Sokuon perception systematically.

The present study conducted a perception experiment using synthetic sounds, non-sense disyllables /V1CV2/ (/ata-/atta/), as stimuli. Two transitional patterns of the first and second formants, F1 and F2, of /V1/ were used to synthesize the stimuli, i.e., with or without formant transition (FT1 or FT0, respectively). The closure duration of /C/ was gradually lengthened in 15 levels and the damping of intensity was not included in /V1/ in order to eliminate the effect from the intensity damping (see Fig.1). The stimuli were repeated three times and randomized when they were presented to participants. 25 native Japanese listened to the stimuli and evaluated them either singleton or geminate consonant.

Figure 2 shows two sigmoidal functions of the proportion of geminate stop responses as function of the /C/ closure duration, each of which corresponds to one of the two formant transitional patterns. There are two main findings from the present study. First, geminate responses increase as closure duration increase. It supports previous studies that claim the closure duration is the primary cue of Sokuon perception. Second, FT1 utterances are perceived as Sokuon with shorter /C/ closure duration (see Fig.2). The cross-over point is 205 ms on FT1 and 248 ms on FT0. Furthermore, from the observation of geminate responses on Fig. 2, when the response is 50% on FT1, the response on FT0 is 21% by only having removed the formant transition from the FT1 utterance. And FT0 utterances tend not to be perceived as Sokuon even though the /C/ closure duration is 380 ms (the longest duration in the present study). This tendency is also reported in Yanagisawa and Arai (2013) using a natural speech. It is presumably because the formant transitions reflect the acoustical characteristics due to the tongue movement at the end of the preceding vowel and are necessary for Sokuon whereas it is not the case for the non-Sokuon context. Sokuon is assumed to be perceived distinctly when the formant transition is accompanied along with the durational cues. From these discussions above, it can be concluded that a formant transition affects Sokuon perception as one of the non-durational cues.

Figure 1: Parameter changes in time for the formant synthesis

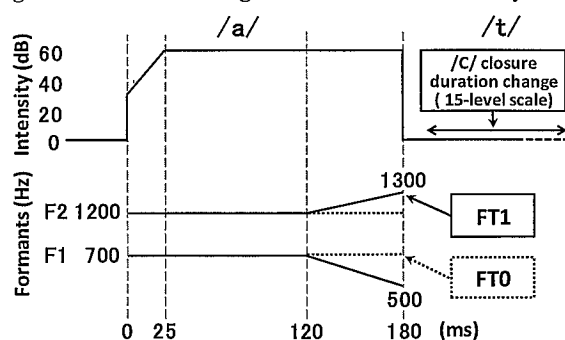
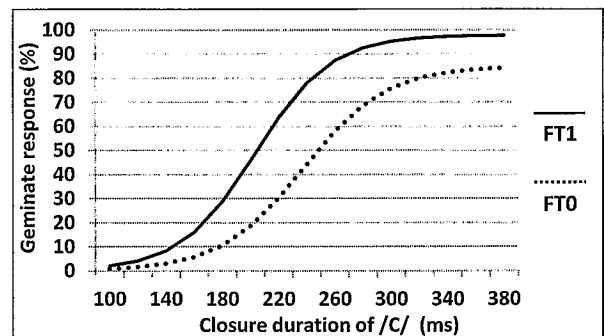


Figure 2: % response of geminates vs. /C/ closure duration with and without formant transitions



References

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