Ann.Bull.RIPL No.29(1995)59-66

Sokuon-ka of Words as a Result of Unfocussing in Fast Speech in Japanese

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1. Introduction

Sokuon /Q/ is a moraic phoneme in Japanese language, which is generally pronounced as a geminate consonant through assimilation to the following consonant (e.g. /iQta/ [itta] (went), /gaQkoo/ [gakkoo] (school)). In kana-transcription /Q/ is denoted by [っ]. There is another type of word that tends to be pronounced with geminate consonants in casual or fast speech, although those words contain no [っ] in normal kana-transcription. This phenomenon is generally referred to as "sokuon-ka". For some words which frequently exhibit sokuon-ka, two parallel methods of kana-transcription, with and without /Q/, are given in some dictionaries (e.g. /tekikaku/ and /teQkaku/ for "tekikaku (adequate)". For some compound words, especially Sino-Japanese compounds, sokuon-ka is regarded as a morphophonemic process. This sokuon-ka occurs when the last Chinese character of the first compound member consists of a voiceless consonant and high vowel and the first Chinese character of the second compound member consists of a initial voiceless consonant. As a result, pairs of words such as /gaQkai/ [gakkai] (academic society) and /gakugai/ [gakugai] (outside of school) arises.

It is generally known that many instances of sokuon-ka are related to the devoicing of vowels; i.e. high vowels between voiceless consonants cause or trigger sokuon-ka. Sokuon-ka is observed, however, even in environments in which vowel devoicing is not considered as its direct cause. For example, /hatsuon/ (pronunciation), /nichiyoo/ (Sunday) and /katsuo/ (bonito) are occasionally heard in fast or casual speech as [hattson], [nitt͡ʃoo] and [kattso], respectively. The process responsible for this type of sokuon-ka is that the -CV(J)V sequence turns into a -QC(j)V sequence. Here, *j* is a glide consonant. The same process can be assumed to occur in the course euphonic change, such as in /uchiyaru/ → /uQcharu/ (utchari technique of Sumo wrestle) and /setsuin/ → /seQchin/ (toilet). Traditionally, this change has been treated as idiosyncratic (Sinmura 1927). From these instances, the following rule can be induced; i.e. -CV(J)V → -QC(j)V. The rule has two important aspects: one is that the closure period of a voiceless consonant becomes long enough to be perceived as a geminate; the other is that the following CV(J)V segment shortens to compensate for the lengthening of the preceding closure period, so that the overall number of morae in the word does not change. To clarify the mechanics of the sokuon-ka phenomenon, the durational characteristics of this type of words were analyzed. The primary focus was on how the duration of the word-medial closure period of the voiceless consonant and that of the following -CVJV sequence changes with respect to speech rate and focussing.

2. Experiment

Subjects: Ten Tokyo dialect speakers (born and raised mostly within the Kanto area)

Test words: NICHIYOO, GETSUYOO, MOKUYOO. These words are days of the week (hereafter, yoobi-words) consisting of a four-mora $C_1V_1C_2V_2JV_3V_4$ sequence.

Type U (unfocussed) sentences: focus is neither on the test words nor on any other yoobi-words found in the sentence.

"Kyoo-wa (A)-bi desu,shigoto-ni iki-masu, kinoo-wa (B)-bi-de oyasumi-deshita"

(Today is (A)day, I am going to work, yesterday was (B)day, I was off.)
Test words are assigned to the blank (B) one at a time to derive three sentences. Yoobi-word pairs placed in the blank of type U sentences are as follows.

	A	B (test words)
U-1	GETSUYOO	NICHIYOO
U-2	KAYOO	GETSUYOO
U-3	KINYOO	MOKUYOO

Type F (focussed) sentences: focus is on the test words as well as the other yoobi-words.
"Kanojo-wa (C)-bi (D)-bi, watashi-wa (E)-bi (F)-bi."
((C)day and (D)day for her, (E)day and (F)day for me.)
Yoobi-words placed in the blanks of type F sentences are as follows.

	C	D	E	F
F-1	KAYOO	KINYOO	DOYOO	NICHIYOO
F-2	SUIYOO	MOKUYOO	KAYOO	GETSUYOO

Since type F sentences are used only when yoobi (days of the week) are the central thing attended to, focus seems to be more emphasized on the test words, as well as on the other yoobi words, in these sentences. This is not the case in type U sentences. Since the difference in focussing can be expected to affect the carefulness of pronunciation, the test words in type F sentences might be pronounced more carefully than those in type U sentences.
Procedure: Subjects were asked to utter 1) type U sentences (U-1, U-2, U-3) at fast speed (type UF utterances), 2) type F sentences (F-1, F-2) at normal speed (type FN utterances), 3) type F sentences (F-1, F-2) at fast speed (type FF utterances) three times each (10x3x3=90 samples in sum). Before the experiment, subjects practiced the U-1 sentences with /nichiyoo/ 2 or 3 times at different speeds. There were 28 total practice samples for the 10 subjects. All the utterances were recorded in a recording studio with a DAT tape recoder. The test words were analyzed using a sound spectrograph (RION SP-09, wide band, 2.4 sec, 0-8 kHz). Each test word was divided into three parts: 1) C_1V_1 (i.e. "ni", "ge" and "mo"), 2) the closure period of C_2, and 3) the remaining $C_2V_2JV_3V_4$ part (excluding the closure period). The duration of test words (Ⅰ) and their three segments (Ⅱ) were converted from the measurement of the sound spectrograph. The ratio of the duration of each part to the duration of the entire test word (Ⅱ / Ⅰ) was calculated as a measure of the "relative duration" of each part. The boundaries of the vowels and consonants were determined by visual inspection based on the following cues: the spike (for /g/, /tʃ/, /ts/ and /k/), the beginning of the nasal formant (for /n/ and /m/), the beginning of frication (when affricates were pronounced as fricatives) and the cessation point of F1 and F2 (for vowels before the closure period and at the end of a test word).

3. Results

3.1 Relative duration of C_1V_1, closure of C_2 and $C_2V_2JV_3V_4$

Figure 1 shows the durational characteristics of each test word in the type FN, FF and UF utterances. The ratios of the duration of C_1V_1, the closure period of C_2 and $C_2V_2JV_3V_4$ (excluding the closure period) to the duration of the entire word are shown. Hereafter, these values will be referred to as the relative duration of C_1V_1, the closure period and $C_2V_2JV_3V_4$.

Each value in Figure 1 is an average of 30 samples. At the right hand side of Figure 1 are shown the averaged speech rates (number of morae/second). It can be seen in the figure that, regardless of the identity of the test words, the ratios of the relative duration of the closure period of C_2 as well as C_1V_1 increase in the order of FN<FF<UF. In a comparison of utterance types FN and FF, the relative duration of FF is longer than that in FN. Further comparison of FF and UF reveals that the relative duration of the closure period is longer in UF than in FF. That is, it was found that, in fast speech, the ratio of the closure duration of word-medial stops and affricates to the entire word duration becomes longer. This ratio increases even more when focus is not on the target words.

Corresponding to this, the ratio of the relative duration of the remaining $C_2V_2JV_3V_4$ part decreases in the order of FN>FF>UF regardless of the test words. This means that the ratio of the duration of the $C_2V_2JV_3V_4$ part to the entire word duration decreases in fast speech. This ratio decreases even more when focus is not on the test word. In UF, especially, the relative duration of this part becomes as small as half of the entire word, although the $C_2V_2JV_3V_4$ part consists of three morae in four-mora words. Since Japanese is considered to be mora-timed, the relative duration of 0.5 is considered, conceptually, to correspond to a two-mora duration. As a matter of fact, on the spectrogram printout of the type UF utterances, adjacent segments were often contracted and the segmentation of phonemes was often difficult. The following two factors can be considered possible causes of the shortening of the $C_2V_2JV_3V_4$ part: 1) the shortening or deletion of the high vowel V_2, or 2) the shortening of *J*. Either one of these causes or their multiplicative effect may function to contract this part of the word. Further analysis is needed to clarify the characteristics of this shortening process.

Due to the experimental design, the systematic data of this experiment do not include the utterances of type U sentences at normal speed (UN). During the practice sessions, however, utterances of U-1 sentence produced at normal and fast speech rate were obtained; hereafter, these utterances are refereed to as type UP utterances. To take an advantage of having this supplementary data for the test word /nichiyoo/, we made a further examination of the relative duration of the closure period with respect to these utterance types. The samples in UP, which totaled 28 , were divided into two groups with respect to their speech rate: a normal speech rate UPN (normal) for 8 samples, and a fast speech rate UPF (fast) for 20 samples. UPF contained utterances with a speech rate faster than 10 morae/ second.

Figure 2 shows the durational characteristics of /nichiyoo/ in the practice sessions. In a comparison of FF and UF in Figure 1 and UPF, the averaged speech rate of UPF is nearly the same as that of FF. However, the relative duration of the closure period in UPF is nearly the same as that in UF, and is clearly longer than that in FF. Thus, this confirms the fact, seen in the fast speech rate, that unfocussing has an effect of closure lengthening. Further comparison of FN in Figure 1 and UPN reveals that the relative duration of the closure period is longer in UPN than in FN, although their speech rates are nearly the same. Eventually, it was found that the effect of unfocussing can be seen for utterances at both a normal and a fast speech rate, although the data for UPN is limited to /nichiyoo/ and the number of samples are also limited. In a comparison of UF in Figure 1, UPN and UPF, the relative duration of the closure period does not differ much, or even decreases in the order of UPN, UPF and UF, although the speech rate increases in the same order. Namely, the effect of a fast speech rate on closure lengthening seen

in the focussed sentences was not seen in unfocussed sentences. It is, thus, concluded that the effect of speech rate depends on the type of utterance; i.e. on whether focus is present or not.

3.2 Distributional pattern of the relative duration of the closure period

Figure 3 shows the distributional pattern of the relative duration of the closure period of each test word with respect to the utterance types. Examination of the distribution of the relative duration of the closure period reveals that, regardless of the test words, the range of the variations was very large in FF and in UF. There are samples in UF whose relative duration of the closure period is nearly twice the average. Such long relative duration of the closure period might be heard as geminate consonants. As for the duration of the closure period of geminate consonants, opinions based on the data in analytical studies are divided between pro (Han 1962,1992, Homma 1981) and con (Beckmam 1982) regarding the Mora hypothesis: the former claims that the duration of the closure period of CC is nearly the same as the duration of one mora; the latter asserts that it is less than one mora. The duration of the closure period of CC is thought to differ with respect to the phonemic environment or the number of morae in a word. There is no data on the duration of /Q/ which is directly applicable to the test words in the present study. However, if we tentatively take the data from Beckman (1982) that the duration of the closure period of CC (VOT as part of vowel) is 171ms and that of CV is 162 ms, then the relative duration of the closure period of CC in a four-mora word ($171 \div 162 \times 4$) will be around 26.4%. Considering these data, we counted the number of samples whose relative duration of the closure period was longer than 0.264 as possible candidates which might be perceived as CC.

Table 1 shows the number of samples whose relative duration of the closure period was longer than 26.4%. In the type UF utterances, there was 4 to 6 times as many samples which satisfied this condition, whereas there was only one in the type FF utterances. Such samples were found as well in the data of the practice sessions (UPN and UPF), even in the utterances at a normal speech rate (UPN).

Table 1. The number of samples whose relative duration of the closure period was longer than 26.4%
(samples total 30 for each group except UPN and UPF)

	FN	FF	UF	UPN (8)	UPF (20)
NICHIYOO	0	0	4	1	2
GETSUYOO	0	0	5	-	-
MOKUYOO	0	0	6	-	-

Further examination of the distributional pattern reveals that the pattern of changes in the relative duration of the closure period due to speech rate and focussing varies considerably from subject to subject. All of the samples except one, whose relative duration of the closure was longer than 26.4%, were uttered by a few subjects. On the other hand, there were subjects whose relative duration of the closure period decreased more in FF and UF than in FN, which is the opposite of the average tendency. Some of these subjects were found to be, or to have been, involved in a narrative club or language teaching. It appears that these subjects tried to keep a normative pronunciation, as in producing tongue twisters, even for the type UF utterances.

4. Summary and discussion

In the present study, we examined the durational characteristics of the word-medial closure period of stops and affricates in CVJV sequences with respect to focussing and speech rate. It was found that, as for the effect of focussing, the relative duration of the closure period becomes longer when focus is not on the target word. This seems to be because for unfocussed sentences the tension for the pronunciation is reduced and, consequently, the articuratory movements for the consonants become slower. As for the effect of speech rate, it was found that the relative duration of the closure period becomes longer at a fast speech rate when the focus is on the target word, whereas it does not differ much regardless of speech rate when focus is not on the target word. Another point to be noticed here is that, in unfocussed sentences and/or at a fast speech rate, the relative duration of the word medial closure period may become longer than 26.4%, which corresponds to a one-mora duration. It can be expected that some word-medial closure period (26.4%) may be perceived as geminate consonants. A separate perceptual experiment is needed to confirm this point. Although the conditions of the present experiment and the number of samples are limited, the results seem to favor the hypothesized sokuon-ka rule of -CVJVV → -QCjVV.

References

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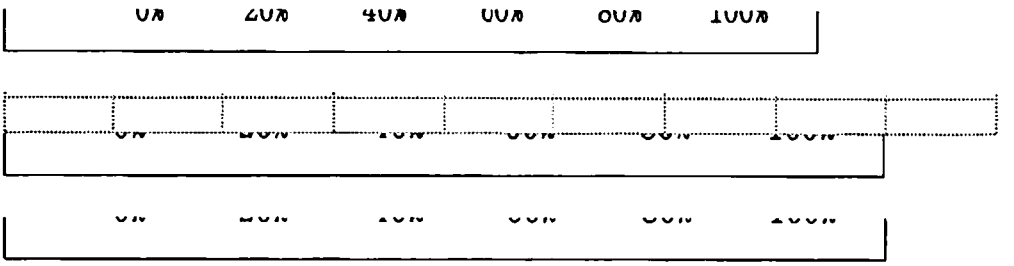
Figure 1. Relative duration of C_1V_1 , closure period, and $C_2V_2JV_3V_4$ part (%)
- Avarage of 30 samples

Figure 2. Relative duration of C_1V_1, closure period, and $C_2V_2JV_3V_4$ part (%)
- Average of 8 and 20 samples, respectively

Figure 3. Distribution of the relative duration of the closure period
-30 samples for each utterance types



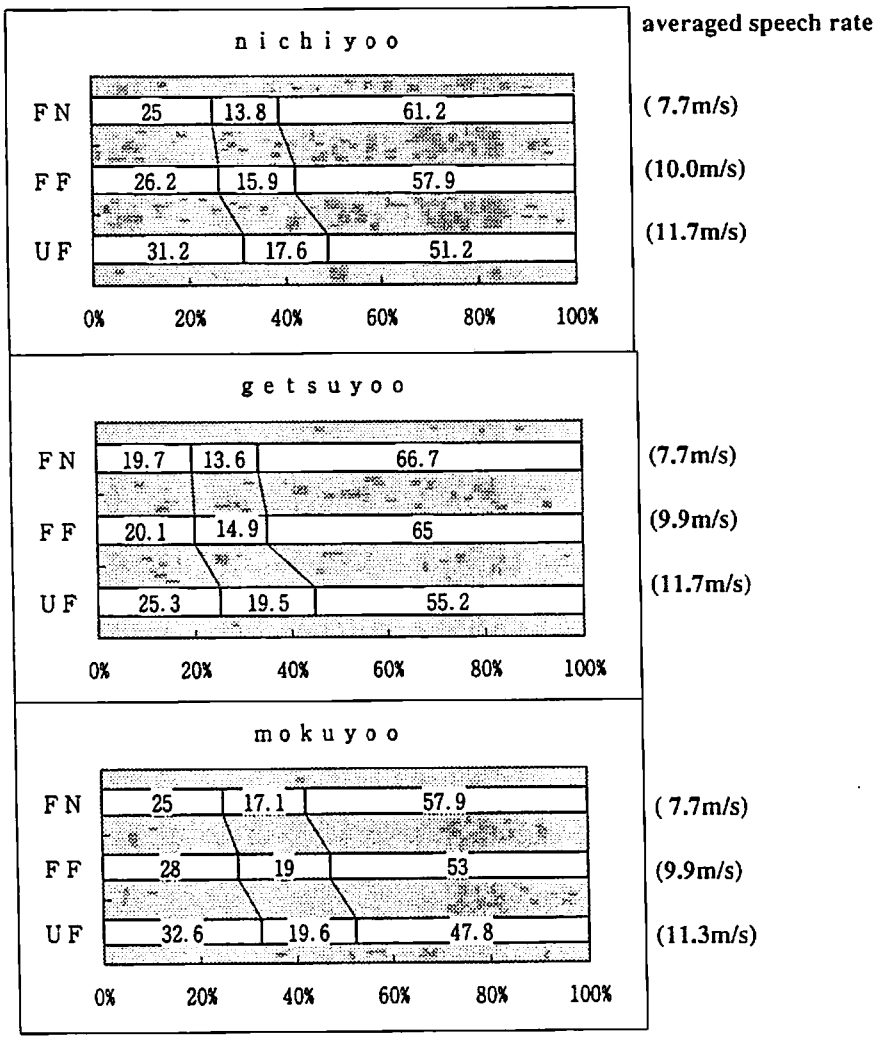


Figure 1. Relative duration of C1V1, closure period, C2V2JV3V4 (%) (average of 30 samples)

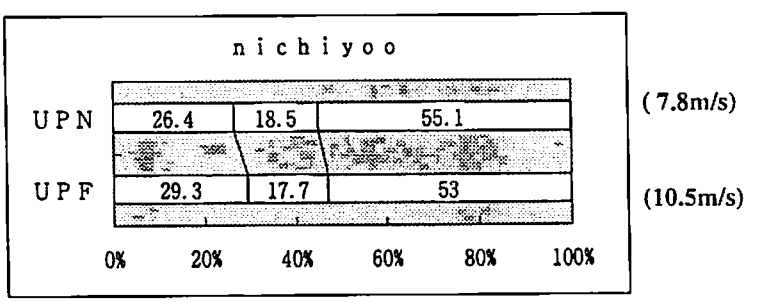


Figure 2. Relative duration of C1V1, closure period, C2V2JV3V4 (%) (average of 8 and 20 samples, respectively)

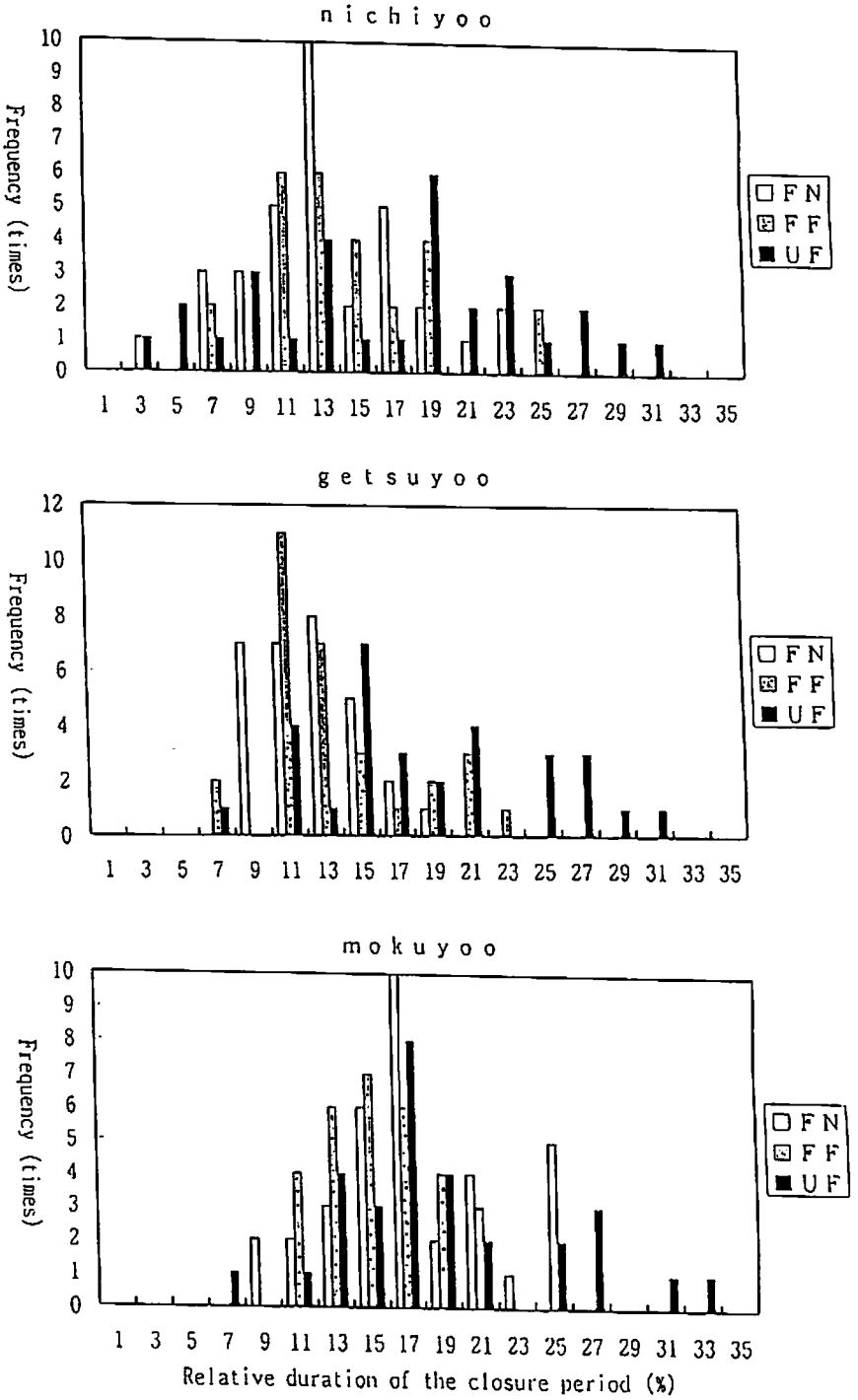


Figure 3. Distribution of the relative duration of the closure period -30 samples for each utterance type