

An experimental study of the perception of Japanese 'SOKUON'

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1. INTRODUCTION

There are two different points of view as to the acoustic characteristics of the sokuon.

First, the difference between the sokuon and normal short consonants is only in the duration. So the sokuon is considered as a kind of long consonant.

In this view, for example, Han (1962: 71) said "There are, however, some cases where the duration of consonants does have a contrastive function. Such a contrast is found in the following examples /iki-/ikiki/"

Secondly, the sokuon has a particular acoustic feature, and this feature makes us hear that sound as a sokuon.

In the latter view, for example, Nakano (1974) reported that if one inserted a blank section of a tape in a closure of stops to make a sokuon from the normal consonants, those sounds would sound somewhat different from the natural sokuon. And he thought that this was because of the lack of the sokuon features in the normal consonant.

Sugawara et al. (1977: 41-44) also reported that they had cut a magnetic tape recording of the word /kata/ between /ka/ and /ta/, inserted a blank piece of tape as the silent part of /katta/, and made a perception test, but they couldn't perceive it as the sokuon.

So, I conducted an experiment of the perception of sokuon to clarify those conflicting views of the sokuon.

2. MATERIAL

The sokuon and non-sokuon pairs of this experiment are as follows:

Nos. 1-4 are samples of stops, Nos. 5 and 6 are samples of fricatives, and No. 7 is a sample of an affricate. The figures in the right end column are the number of stimuli. Each stimulus was made from the natural speech sound which included sokuon in the speech database at ATR (Advanced Telephony Research Institute International). The stimulus synthesizing processes for the stops and affricates are obtained by removing silent sections before bursts in 10 msec. setps. As for the fricatives, cutting off the frication produced the fricative stimuli. This database consists of approximately 5,000 common Japanese words, 200 phonetically balanced words,

Table 1

	sokuon	non-sokuon	
1	/akka/ "to become worse"	/aka/ "dirt"	23
2	/ikka/ "family"	/ika/ "below"	16
3	/otto/ "husband"	/oto/ "sound"	18
4	/sakku/ "case"	/saku/ "to tear, split"	11
5	/sassuru/ "to guess"	/sasuru/ "to rub"	12
6	/zissju:/ "practice"	/zisju:/ "studying by oneself"	13
7	/sjuttjo:/ "business trip"	/sjutjo:/ "assertion"	11

100 Japanese CV-syllables, and a small number of short sentences. These words were spoken in isolation by a professional male announcer. With the database management tool, anyone can access easily to speech files.¹⁾

The tool used in this synthesizing procedure is a sound manipulating system executed on μ -vax²⁾.

Prior to this experiment, I made a preliminary test to check the naturality of each stimulus.

3. EXPERIMENT

Ten Japanese native speakers were the subjects of this experiment. Each stimulus set was repeated two times in random order. It follows that each stimulus was judged for 20 repetitions in total.

In this identification test, the experiment type was 2AIT (Alternative Identification Test). This means that the subject was forced to judge whether the stimulus was a sokuon or non-sokuon. So any ambiguous answer was prohibited (he couldn't reply "I can't tell which is which").

4. RESULTS

4.1. Stops

4.1.1. /akka/-/aka/

For this stimulus, the categorical boundary point was 170 msec. When the closure was longer than 215 msec, all subjects identified a sokuon. On the other hand, when the closure was shorter than 115 msec, no subjects heard the stimulus as a sokuon.

1): K. Takeda, S. Morikawa, H. Kuwabara: "Construction of Japanese speech database management system," Meeting of Information Processing Society of Japan, 2H-4, September, 1987.

2): Used by the courtesy of Dr. A. Kurematsu, the president of ATR Interpreting Telephony Research Laboratories

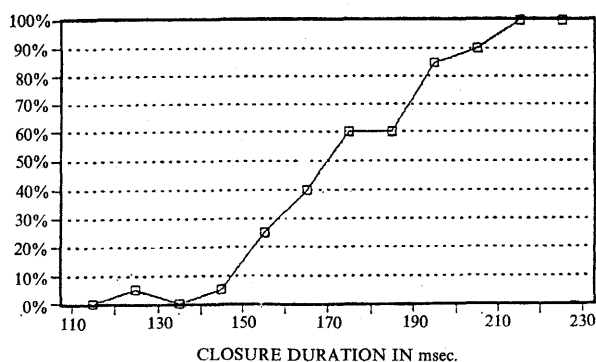


Fig. 1. Results of identification test for the distinction /akka-/aka/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

4.1.2. /ikka-/ika/

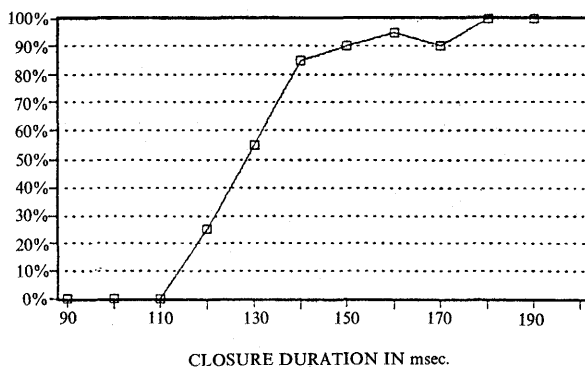


Fig. 2. Results of identification test for the distinction /ikka-/ika/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

The categorical boundary point of this pair was 128 msec. When the closure was longer than 150 msec, 90% of subjects identified a sokuon. And when it was shorter than 110 msec, no subjects perceived the stimulus as a sokuon.

4.1.3. /sakku-/saku/

The categorical boundary point was 141 msec. When it was longer than 170 msec, 95% of subjects identified a sokuon. And when the closure was shorter than 100 msec, no subjects heard the stimulus as a sokuon.

4.1.4. /otto-/oto/

The categorical boundary point of this pair was 162 msec. When the closure was longer than 195 msec, 90% of subjects identified a sokuon. And when it was shorter than 135 msec, no subjects heard the stimulus as a sokuon.

4.2. Fricatives

4.2.1. /sassuru-/sasuru/

The categorical boundary point of this pair was 162 msec. When the frication

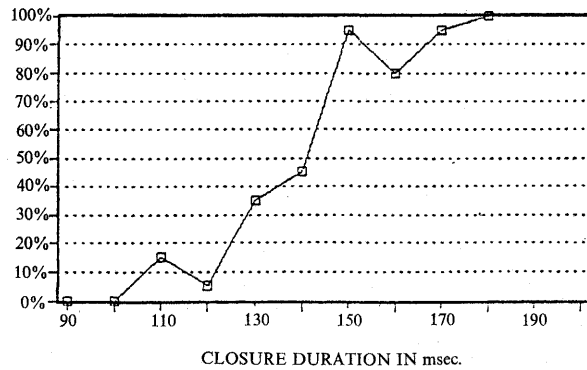


Fig. 3. Results of identification test for the distinction /sakku-/saku/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

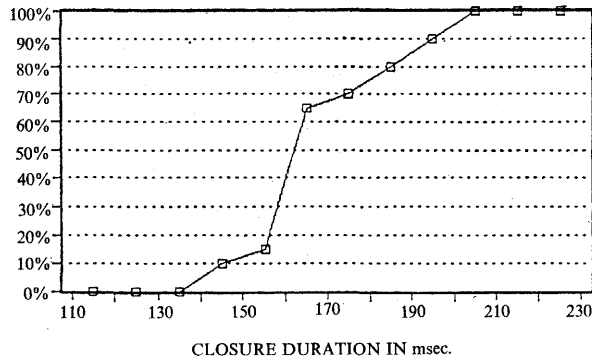


Fig. 4. Results of identification test for the distinction /otto-/oto/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

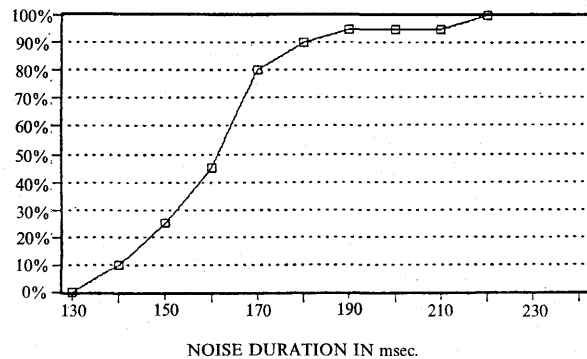


Fig. 5. Results of identification test for the distinction /sassuru-/sasuru/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

was longer than 190 msec, 95% of subjects identified a sokuon. And when the noise was shorter than 130 msec, no subjects heard the stimulus as a sokuon.

4.2.2. /zissju:/-/zisju:/

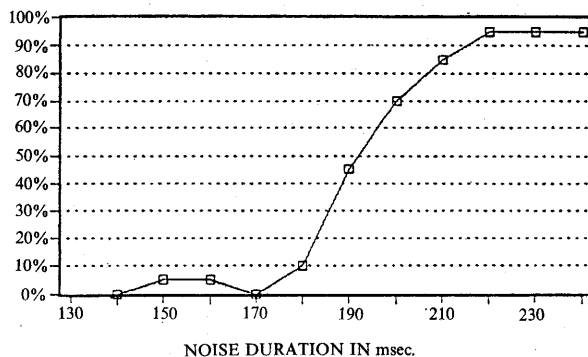


Fig. 6. Results of identification test for the distinction /zissju:/-/zisju:/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

The categorical boundary point of this pair was 192 msec. When the frication was longer than 220 msec, 95% of subjects identified a sokuon. And when it was shorter than 170 msec, only one of the subjects heard the stimuli as a sokuon.

4.3. Africate

4.3.1. /sjuttjo:/-/sjutjo:/

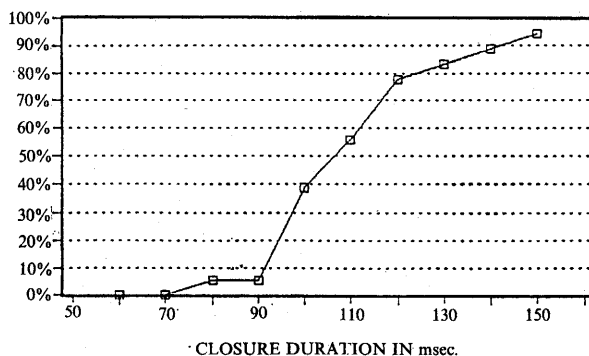


Fig. 7. Results of identification test for the distinction /sjuttjo:/-/sjutjo:/ pair. The number on the vertical-axis indicates the percentage of subjects who judged it as sokuon.

The categorical boundary point of this pair was 107 msec. When the closure was longer than 130 msec, 83% of subjects identified a sokuon. And when it was shorter than 90 msec, 94% of subjects heard the stimulus as a non-sokuon.

5. CATEGORICAL BOUNDARY POINT

The boundary point value is computed using the method below;
 Closure (/ noise) duration of categorical boundary point: A

Closure (/ noise) duration of natural sokuon: B

Closure (/ noise) duration of natural non-sokuon: C

$$\frac{A-C}{B-C} \times 100$$

When the boundary point approaches the non-sokuon, the result of this reckoning is close to zero. On the other hand, if the boundary point approaches the sokuon, this value becomes closer to 100.

This value of stops came out as follows:

Table 2 The figures in the right end column are the values of each stimuli set.

/akka/-/aka/	48
/ikka/-/ida/	50
/sakku/-/saku/	51
/otto/-/oto/	51

Though the closure duration of the boundary point varies stimulus to stimulus (128-170 msec), the four values are approximately equal to each other. And all these values are located almost at the center of the closure duration between the sokuon and non-sokuon (48-51).

These values of fricatives and affricate were 38 for /sassuru/-/sasuru/ pair, 50 for /zissju:-/zissju:/ pair, and 52 for /sjuttjo:-/sjuttjo:/ pair.

6. EXPERIMENT 2

If there are some acoustic differences between sokuon and simple long consonants, it follows that there is something different between the perception of the natural sokuon and the synthesized long consonants from single consonants (artificially made sokuon). So, the two types of stimuli (A,B) were made for this second experiment as follows:

Stimulus A: Inserting silent sections in 10 msec. steps into the closure of /k/ of /ika/ to make /ikka/.

Stimulus B: Removing silent sections in 10 msec. steps of the closure of /kk/ of /ikka/ to make /ika/.

I conducted the perception test for the two groups, and checked the differences between the value of the boundary point of the two groups. Eight native Japanese speakers were the subjects of this experiment. The experimental procedure was similar to the first experiment. The results of this second experiment are as follows:

Boundary point of stimulus A: 121.7 msec.

Boundary point of stimulus B: 126.0 msec.

The difference between the result values for A and B was only 4.3 msec. There is no statistically significant difference between these two figures. Therefore there may be no difference between a sokuon and a long consonant.

7. SUMMARY

In this paper, I did two experiments as mentioned above. These experiments revealed the following findings:

1. Boundary point between a sokuon and non-sokuon of stops is located at the center of the closure duration.
2. There is no difference between the perception of natural sokuon and artificial sokuon.

Future research must be done to explain why only this /sassuru/-/sasuru/ pair's value was extremely low.

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