PHONOLOGICAL UNITS IN SPEECH SEGMENTATION AND PHONOLOGICAL AWARENESS

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ABSTRACT

This paper explores the relationship between phonological units in speech segmentation and phonological awareness by investigating Japanese Brazilians living in Japan. The first experiment investigated the size of the phonological unit in speech segmentation using the Japanese materials and methodology in Otake et al. (1993). As for French subjects in the earlier study, the miss rates showed an effect of syllabic segmentation, suggesting that the Japanese Brazilians segmented Japanese into syllables. The second experiment investigated phonological units in phonological awareness, using a mid-chunk-unit search task in which subjects were asked to identify the middle unit within a word. 96% of the mid-chunk unit choices were syllable-based. The results of the two experiments suggest that Japanese Brazilians exploit syllables both as a speech segmentation unit and as a unit to represent within-word structure.

1. INTRODUCTION

Recent studies in speech segmentation have shown that segmentation strategies in continuous speech are highly related to linguistic rhythm. The significant aspect of this claim is that the fundamental nature of these strategies is language-specific and that monolingual human listeners apply these strategies not only to native input but also to foreign input (Cutler et al, 1986). Japanese monolingual listeners, for example, exploited a mora-based segmentation strategy not only for Japanese but also with English, French and Spanish (Otake et al., 1993; Cutler & Otake, 1994; Otake et al., 1996), just as French monolingual listeners exploited a syllable-based strategy with English as well as French (Cutler et al., 1986). Since monolingual listeners know nothing but their own phonological system, it is not surprising that they applied the same segmentation procedure to foreign input (Cutler and Otake, 1994).

Moreover, recent studies have also shown that monolingual listeners represent within-word structure of both native and non-native words with the same phonological units. For example, when Japanese monolingual listeners were asked to identify a phonological unit in Japanese and English to represent within-word structure, they exploited morae not only in Japanese but also in English (Otake and Yamamoto, 1997). This suggests that monolingual listeners are likely to represent both native and non-native words with the same phonological unit, a unit based upon linguistic rhythm.

These two kinds of studies seem to imply that there is a close relationship between phonological units in speech segmentation and phonological awareness exploited by monolingual listeners, in that human listeners may draw on the same strategy which is related to linguistic rhythm both to segment non-native input and to represent them in phonological awareness.

The present paper investigated this issue further testing Japanese Brazilians living in Japan. Brazilian Portuguese has a syllable-timed rhythm. Morais et al. (1979) reported that Portuguese illiterates were sensitive to syllables rather than phonemes in auditory processing in Portuguese. Recent speech segmentation studies with French and Spanish, each of which is a syllable-timed language demonstrated that listeners exploited a syllable-based strategy in continuous speech (Mehler et al., 1981; Sebastian-Galles et al., 1992). Since Portuguese is a syllable-timed language, we hypothesize that the Brazilians listeners would use a syllable-based strategy for non-native input. In other words, when monolingual Portuguese listen to Japanese or are asked to represent within-word structure of Japanese, they would probably exploit a syllable-based segmentation strategy if the earlier findings described were correct. The present paper investigated this hypothesis, by testing Japanese Brazilians living in Japan who could barely communicate in Japanese. There is a very large population of Brazilian citizens of Japanese descent, who however do not command the Japanese language; they have been born and educated in Brazil, and Portuguese is their only language. Many of these Brazilians come to work for longer or shorter periods in Japan; this was the subject

population within which the experiments were conducted. In the first experiment, the size of the phonological unit in speech segmentation was investigated. The second experiment investigated phonological units in phonological awareness.

2. EXPERIMENT 1

2.1. Method

Materials
Stimuli were 8 pairs of words each of which contained the same three phonemes word initially. The third phoneme was a nasal and functioned either as an onset or as a coda. They were *tanishi, tanshi, monaka, monka, kanoko, kanko, sanaka, sanka* for CVC words, *nanoka, nanka, kinori, kinri, haneda, handa, shingao, shinigao* for CV words. These words were arranged into 64 sequences with further 250 words. For more details, see Otake et al. (1993).

Subjects
20 Japanese Brazilians whose age varied from 15 to 28 years old and who had lived in Japan between 1 and 3 years. They participated in the experiment, in returns of a small payment. None of them reported the hearing difficulties.

Procedure
The subjects were tested individually or in pair in a quiet room. All the instructions were given in Portuguese by an interpreter, since their Japanese language proficiency was not good enough to communicate in Japanese. They were instructed to listen for a word beginning with the sounds represented by the Roman characters specified as target for each sequence, and to press a response button as soon as they had detected an occurrence of this target. The target for each sequence was presented visually, on a 15 x 17-cm card, immediately prior to the beginning of the sequence. The sequences were presented over headphones from a DAT recorder. The output from this recorder was also fed via a mixer to a second DAT recorder, which via the same mixer also recorded a pulse triggered by the subject's response. The intervals between onset of the target word and response button were measured individually from each subject on a Kay Sona-Graph 5500 to ascertain reaction times.

Our prediction was that since Japanese Brazilians' linguistic rhythm is syllable timing, they must be sensitive to syllables just as French listeners were in the studies of Cutler et al. (1986) and in Otake et al. (1993).

2.2 Results

The same statistical analyses were conducted as in Otake et al. (1993) to enable direct comparison between their study and our study. Mean number of the missed responses and the mean response times were determined for each subject and each item, and separate analyses of variance were conducted on each measure with subjects and with items as random factors. The miss rate analyses showed an interaction between the size of a visual target sequence and the phonological structure of a stimulus word by both subjects and items (F1 (1, 18) = 10.9823, p < .0039; F2 (1, 12) =22.4534, p < .0005). Further analyses of t-tests (2-tailed) showed that all pair comparisons are significantly different (CV words vs. CVC words in CV target: t1(19) =-2.651, p< .016; t2(6) = -5.229, p < .002; CV words vs. CVC words in CVC targets: t1(19) = 3.265, p< .004; t2(6) = 4.998, p < .002; CV targets vs. CVC targets in CV words: t1(19) = -3.222, p< .004; t2(6) = -2.848, p < .029; CV targets vs. CVC targets in CVC words: t1(19) = 2.797, p< .012; t2(6) = 4.500, p < .004). The response time data are minimally informative, yielding no statistically reliable difference.

	CV words	CVC words
CV targets	12.9	32.1
CVC targets	33.6	12.9

(%)

Table 1. The mean number of missed targets as a function of the size of a visual target sequence and the phonological structure of the stimulus word, performed by the Japanese Brazilians.

The results in Experiment 1 showed that when Japanese Brazilians listened to Japanese, they segmented it into syllables, as we expected. Given the fact that they were sensitive to syllables, this suggests that they exploited a native-rhytm-based segmentation strategy to foreign input, which confirmed the previous findings (Cutler et al., 1986; Otake et al., 1993; Cutler and Otake, 1994).

3. EXPERIMENT 2

3.1 Method

Materials
18 stimulus words and 18 fillers were chosen. The stimuli consisted of three word types, each of which contained 6 stimulus words. They were *sento, panpa, tanku, kanon, demon, parin* for the 3 mora-2 syllable words; *zanboa, tsundora, chinchira, neruson, kokain, tomuson* for the 4 mora-3 syllable words, *koronbia,*

torankusu, granpuri, furamenko, garusonnu, dominanto for the 5 mora-4 syllable words. These words were all mono-morphemic loanwords.

Subjects
The subjects were the same as the ones in Experiment 1.

Procedure
18 stimulus and 18 filler words were recorded randomly in DAT by a native speaker of Tokyo Japanese. The words were presented binaurally through headphones to each subject. The subjects were tested individually in a quiet room. They were instructed to identify a mid-chunk unit within the word and report it, as soon as they listened to each word. If they did not find a mid-chunk unit within a word, they were asked to report that. Before the experiment was conducted, the practice session was carried out, using the words, which were consisted of CV sequences.

Our prediction is that if the previous findings were correct, Japanese Brazilians should be sensitive to syllables in this task. Suppose that *sento* and *chinchira* were presented and they were asked to find a middle chunk unit in each word. Since *sento* is a two-syllable word, there is no middle chunk unit in it, while *chinchira* is a three-syllable word, *chi* is a middle chunk unit. If subjects made this distinction, we would assume that they were sensitive to syllables. On the other hand, since the former is a three-mora word, *n* is the middle chunk unit, while the latter is a four-mora word, so that there is no middle chunk unit. If they were to make this distinction, we would assume that they are sensitive to morae.

3.2. Results

The proportions of two units, mora and syllable are presented in Table 2. Other category includes responses which failed to comply with instructions.

	Mora	Syllable	Others
2 syllable words	1	98	1
3 syllable words	0	98	2
4 syllable words	0	92	8
Total average	0.33	96	3.67

(%)

Table 2. The proportions of responses within three categories, performed by the Japanese Brazilians.

The pattern of responses is very clear and our analysis is confined to simple non-parametric tests. Chi-squared tests show that the patterning of responses across categories was significantly different from that which would be expected by chance (χ^2=836.27, df=2, P<.001).

On average 96% of the mid-chunk-units reported by the subjects were based on syllables. Within each word type, the same tendency was observed. Their response patterns across categories were different from the ones which would be expected by chance (2 syllable words: χ^2=296.45, df=2, p <.001; 3 syllable words: χ^2=296.45, df=2, p<.001; 4 syllable words: χ^2=245.00, df=2, p<.001).

The results in this Experiment show that Japanese Brazilians clearly exploit syllables rather than morae to represent within-word structure of Japanese words. In other words, they applied the native system to represent non-native input.

4. GENERAL DISCUSSION

The results of the two experiments confirmed that Japanese Brazilians exploited syllables both as a speech segmentation unit and as a unit to represent within-word structure. This suggests that human listeners draw on the same strategy both to segment non-native input and to represent them in phonological awareness. In this section we will discuss the following two points.

First, is a rhythm-based segmentation strategy directly applicable to foreign input? In Experiment I we tested whether this hypothetical claim was correct or not. In Cutler et al. (1986) and Otake et al. (1993, 1996), monolingual listeners exploited a rhythm-based segmentation strategy in continuous speech in foreign input as well as native input. French listeners segmented not only French but also English into syllables, while Japanese listeners segmented French and Spanish as well as Japanese via morae. In the present study Japanese Brazilians segmented Japanese via syllables. Given all these facts, we conclude that monolingual human listeners segment continuous speech, whether it is native or foreign, with a rhythm-based segmentation strategy. In this respect, this is a universal phenomenon.

Second, our next concern is whether or not a phonological unit to represent within-word structure is determined by linguistic rhythm. In this study we have examined Japanese Brazilians and found that the phonological unit to represent within-word structure of Japanese was syllables. In the earlier studies it was found that Japanese monolingual listeners exploited morae to represent both Japanese and English (Otake and Yamamoto, 1997). From these results we may want to conclude that listeners' representation of within word structure is determined by linguistic rhythm. However, this is not always true because English listeners exploited syllables to represent within word-structure of

English and Japanese, although English is stress timing (Otake and Yamamoto, 1997; Otake et al., 1998). In these studies, monolingual English listeners were asked to find a chunk unit with a modified task. In this respect, listeners' representations of within-word structure may differ from speech segmentation. Thus, a phonological unit to represent within-word structure is not rhythm-based.

5. CONCLUSIONS

In this paper, we have investigated the relationship between phonological units in speech segmentation and phonological awareness by investigating Japanese Brazilians living in Japan. We investigated two things.

First, Japanese Brazilians segmented continuous speech in Japanese with syllables, suggesting that they exploited a rhythm-based segmentation strategy to foreign input.

Second, Japanese Brazilians exploited syllables to represent within-word structure of Japanese, suggesting that it appears to be rhythm-based. However, this process may not be necessarily related to the rhythm-based strategy because English listeners exploit syllables.

6. ACKNOWLEDGEMENTS

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