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Perceiving continuum of voiceless affricate/fricative by changing rise time of consonant for elderly and younger participants

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ABSTRACT

We have conducted the perception test of voiceless affricate/fricative by changing the rise time of the consonant from long (/ʃ/) to short (/ʧ/) in elderly listeners [Proc. Spring Meet. Acoust. Soc. Jpn., pp. 487-488, 2006]. The stimuli we used were made using the methods of Howell and Rosen [J. Acoust. Soc. Am., Vol. 73, No. 3, 1983]. We have previously found that elderly listeners perceived the long voiceless fricatives as short affricate when compared to younger listeners. The response curves of /ʧ/ for elderly participants were less steep than those of younger participants. In the current study, we created stimuli with and without vowel to investigate the effect of backward masking by the following vowel. We used steady-state suppression to suppress the vowel. Also, we artificially expanded the rise time of voiceless fricative /ʃ/ and made a wider continuum range than our previous study. The purpose of this was to create a wider response curve of /ʧ/ so we could determine the difference between a short- and long-ranged continuum. Ten elderly and 24 younger participants took part in a perceptual experiment. Results showed that elderly participants perceived consonants in a shorter rise time than younger participants. There were no differences among consonant with vowel, without vowel, and processed steady-state suppression. We could not determine the effect of backward masking by the following vowel.

INTRODUCTION

Elderly people often complain about confusion when listening to consonants. This confusion is caused by an elevation in the threshold of hearing levels or an increase in temporal masking [1]. Kobayashi et al. [2, 3] used the steady-state suppression first described by Arai et al. [4, 5] to suppress the steady state portion of speech in attempt to reduce the temporal masking for hearing impaired people. Kobayashi et al. conducted experiments using Japanese monosyllables with elderly participants and reported that some consonants were perceived in different consonant in both processed and unprocessed stimuli. Their results showed that participants incorrectly identified voiceless fricative /ʃi/ as voiceless affricate /ʧi/. We [6] experimented with elderly people using stimuli created by using the methods described by Howell and Rosen (1993)[7]. We have previously used the continuum from voiceless fricative /ʃ/ to voiceless affricate /ʧ/. Steady-state suppression has been used to investigate confusion associated with listening to /ʃ/ and /ʧ/[6]. We have conducted an identification test with elderly and younger participants and reported that the younger participants had a quicker categorical response for perceiving /ʧ/. The response curve of /ʧ/ in elderly participants was not as steep as the curve for younger participants. In the current study, we focused on the backward masking produced by the following vowel. We created stimuli that had a longer rise time at voiceless /ʃ/ frication and conducted experiments with elderly and younger participants. We used the steady-state suppression to suppress the following vowel and to reduce the backward masking. We also used stimuli that had the following vowel deleted (only consonant) to investigate the effect of backward masking by vowels.

EXPERIMENTS

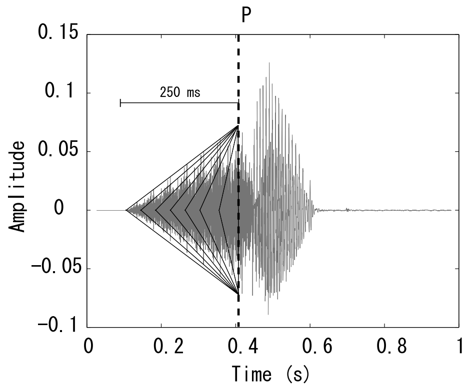

Fig. 1. Multiplying linear slope at rise part of voiceless fricative /ʃ/. P represents the maximum amplitude of frication.

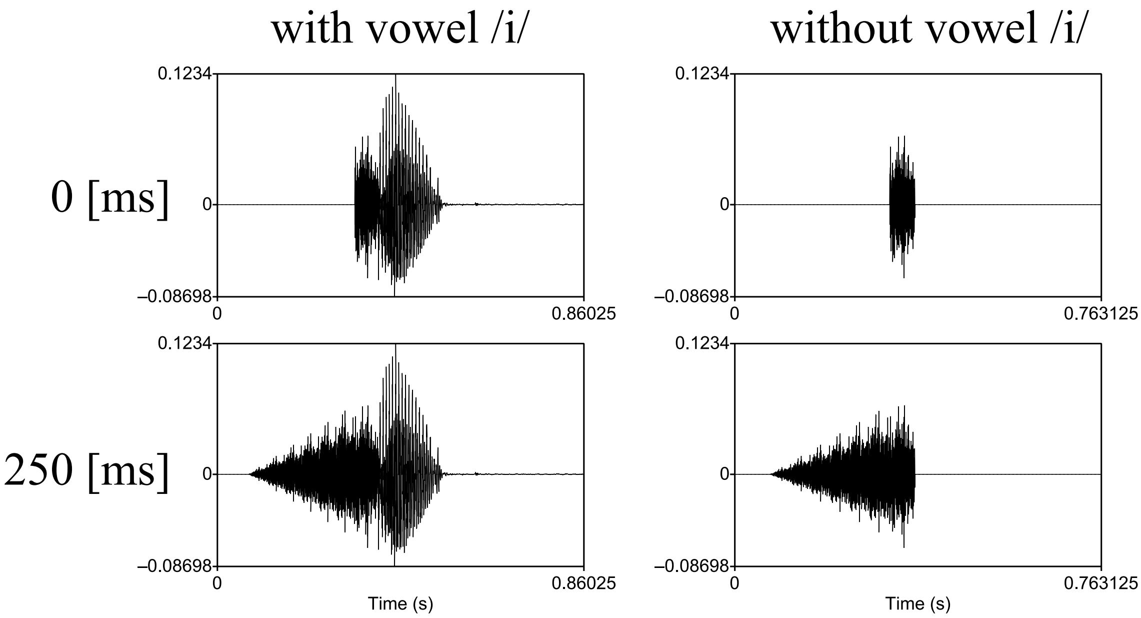

Fig. 2. Representative stimuli with/without vowel in 0 ms and 250 ms rise time

STIMULI Our previous research has followed the method of Howell and Rosen (1983) to create stimuli[6]. In the current study, we basically followed the method of Howell and Rosen (1983) but created stimuli based on /ʃi/ pronounced by a Japanese male. First, the rise part of /ʃ/ was divided by using an envelope to create flat frication. Second, the flat frication was repeated to extend the frication. Third, the linear slopes were multiplied to create 26 different rise times (0 to 250 ms in 10 ms steps). Figure 1 shows multiplying the linear slope on /ʃ/ according to the method of Howell and Rosen (1983) [7]. The slope in the left part of Figure 1 shows that the maximum amplitude of frication changed from 0 to 250-ms rise time.

Steady-state suppression has been used to investigate the effect of reducing the amplitude of the following vowel. This is because the following vowel creates backward masking on the previous consonant. We previously have used a suppression rate of 40 % [6].

We created stimuli with and without the following vowel to investigate the effect of the backward masking by the following vowel. Figure 2 shows the representative stimuli with and without vowels in rise times of 0 ms and 250 ms.

A total of 104 stimuli (26 rise times with and without steady-state suppression and with and without the following vowel) were used in the experiment.

PARTICIPANTS Elderly participants included 10 native speakers of Japanese. They all have lived in Chiyoda City, Tokyo. None of them have been diagnosed as suffering from mental disorders, such as dementia, nor have had a history of wearing hearing aids. Figure 3 shows the audiograms of the elderly participants. Younger participants included 24 native speakers of Japanese. None of these participants have ever had hearing problems.

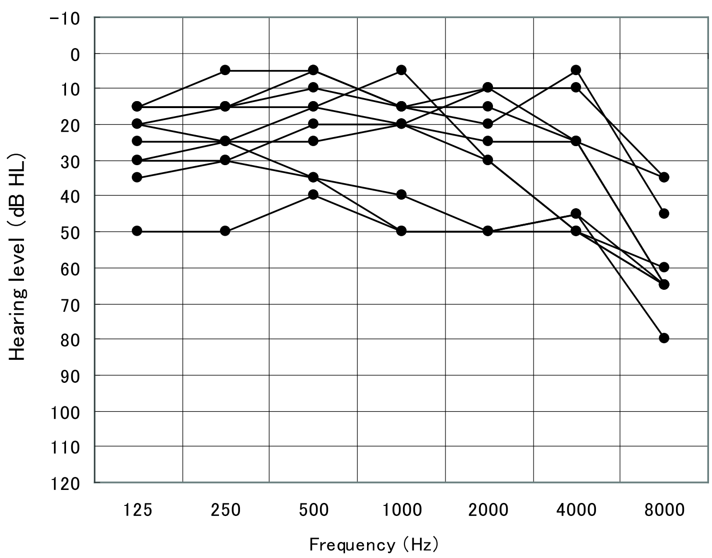

Fig. 3. Audiograms of elderly participants

PROCEDURE A computer controlled listening test was conducted in a sound proofed room. The stimuli were presented over headphones (STAX SR-303) using a USB audio interface (ONKYO SE-U55X). The sound level was adjusted to a comfortable level for each participant prior to testing and maintained throughout the test. The elderly participants were asked to write down the /ʃi/ or /ʧi/ on response sheet in Japanese. Whereas, the younger participants entered /ʃi/ or /ʧi/ on a separate laptop computer in Japanese. Before starting the experiment, participants had practice trials to become familiar with the procedure. Participants listened to 0-ms and 250-ms rise time stimuli for practice. The experiment was conducted in two sessions. In the first session, stimuli that had the following vowel /i/ were used. In the second session, stimuli without the following vowel were used, and participants were asked to wrote down the /ʃi/ or /ʧi/ instead of the stimuli that did not contain the vowel /i/.

RESULTS AND DISCUSSIONS

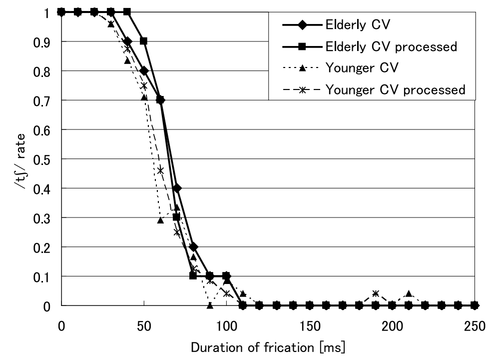

Fig. 4. Response curves of /ʧ/ with vowel /i/

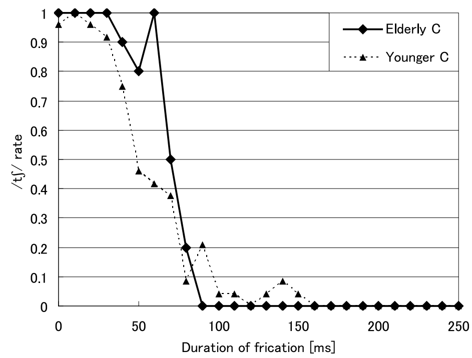

Fig. 5. Response curves of /ʧ/ without vowel /i/

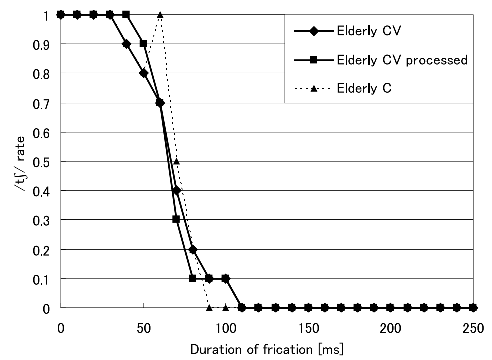

Fig. 6. Response curves of /ʧ/ by elderly participants

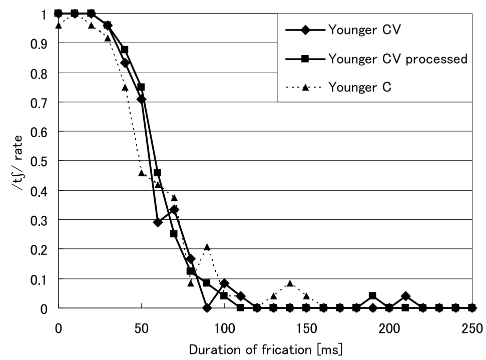

Fig. 7. Response curves of /ʧ/ by younger participants

Figure 4 shows the response of /ʧ/ with the following vowel /i/. Figure 5 shows the response without the following vowel. In both figures, the response curves of the elderly participants (solid line) shifted to the right when compared to the response curves of the younger participants (dotted line).

EFFECT OF BACKWARD MASKING Figures 6 and 7 show the response curves of the elderly participants and younger participants for /ʧ/. In both figures, the solid line represents the response curves with the following vowel, and the dotted line represents the response curves without the following vowel. The results in these figures showed there is no difference in stimuli for both groups of participants. Figure 4 shows the response curves with the following vowel. The result in this figure also shows that there is no difference between elderly and younger participants in the presence and absence of steady-state suppression.

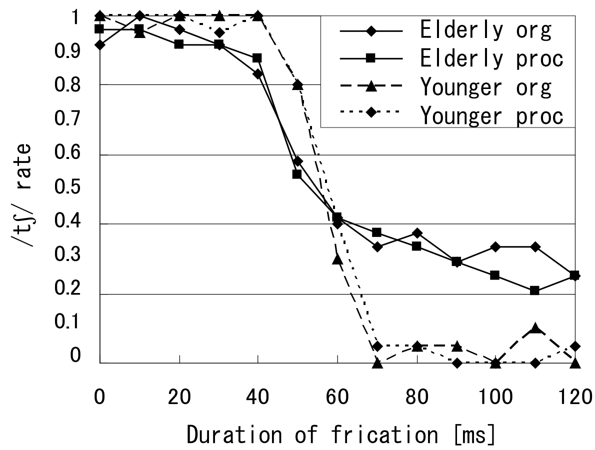

Fig. 8. Response curves of /ʧ/ in Yasu et al.[6]

COMPARISON WITH PREVIOUS RESEARCH Figure 8 shows the response curves of /ʧ/ from our previous research[6]. In that study, 23 elderly participants and one younger participant took part in the experiments. The younger participant repeated 20 sessions. Figure 8 shows that a categorical response was given by the younger participant (dotted line). The response curve of /ʧ/ in the elderly participants (solid line) was not as steep as the younger participant. At the cross over point of response (0.5), the rise time was almost the same for elderly and younger participants. At a rise time of 80-120 ms, the younger participant had a response rate for /ʧ/ of zero, but the elderly participants had a response rate for /ʧ/ of around 0.2 to 0.3. Comparing the result of this study (Figure 4) and our previous study, (Figure 8), we found that the response of elderly participants is much closer to that of the younger participant in this study. In addition, the response rate was almost zero at 100 ms for both groups of participants. These result show that a relatively shorter stimuli was perceived as /ʧ/ for the rise-time range between 0 and 250 ms used in this study. This is different than our previous study [6], in which the range was between 0 and 120 ms. The stimuli of the previous study were made by multiplying the linear slope and original /ʃ/ stimuli. As a result, the rising slope might be parabolic instead of linear. The difference in the rise of the slope might account for the difference in the response curves of /ʧ/.

FRICATION DURATION AND AMPLITUDE RISE SLOPE Kluender and Walsh (1992) [8] conducted two different experiments and suggested that the changes in rise time that used at previous research[7, 9]were not sufficient to signal the distinction between fricatives and affricates [10]. Mitani et al. created the continuum of voiceless fricative to affricate by changing rise function, frication duration, and amplitude rise slope. They concluded that frication duration and amplitude rise slope are acoustic cues for discriminating between /ʃ/ and /ʧ/, and these two cues interact with each other [10]. In the case of elderly listeners, the perception of frication duration and amplitude rise slope might different from that of younger listeners.

CONCLUSION

We conducted experiments in which elderly and young participants perceived the continuum of voiceless fricative /ʃ/ to voiceless affricate /ʧ/. Elderly listeners perceived consonants, or categorized stimuli in a shorter rise time than younger listeners. There were no differences among consonant with vowel, without vowel, and processed steady-state suppression[4, 5]. Our future work will involve conducting experiments with stimuli that considers the frication duration and amplitude rise slope for elderly participants.

Acknowledgements

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