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THE EFFECTS OF THE CONSONANT STRESSING FUNCTION OF THE HD-10 DIGITAL HEARING AID

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The effects of the consonant stressing function of the HD-10 digital hearing aid (abbr. HD-10) on speech discrimination scores were studied in 15 patients with moderate or severe sensorineural hearing loss and compared with analogue hearing aids. When the electroacoustic characteristics were set identical for both hearing aids, the speech discrimination scores for the HD-10 without the consonant stressing function were the same as those for the analogue hearing aids in 12 cases. However, the results for the HD-10 with the consonant stressing function were better than those for the analogue hearing aids in eight cases. With the consonant stressing function, the discrimination of Japanese consonants was significantly improved, in particular in voiceless consonant /s/, voiced consonant /b/, fricative consonants /g/ and /z/, bound consonant /r/ and semi-vowels /w/ and /y/.

1. INTRODUCTION

Poor speech discrimination ability of Japanese patients with sensorineural hearing loss is caused mainly by their confusion of consonant sounds. In fitting hearing aids for such Japanese patients, it is therefore important that the ability to discriminate among consonants is improved. To achieve this, it is necessary to adjust the gain and frequency response of the hearing aid. Since the majority of Japanese consonants are distributed from 1000–4000 Hz [1], consonant discrimination ability can be improved with hearing aids by emphasizing middle and high frequency ranges in general [2]. Furthermore, the output levels of hearing aids should be increased up to 10–15 dB from the linear amplification level, because the intensity level of Japanese consonants is 10–15 dB lower than vowel sounds [1]. However, it is not possible to use this strategy for improving speech discrimination with analogue hearing aids.

In contrast, the HD-10 has various input and output characteristics. This is because the HD-10 receives sound through a microphone, separates it into low, middle and high

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frequency ranges and then converts analogue signals to digital form. The HD-10's consonant stressing function can be selected at three grades of non-linear amplification as strong, moderate and weak. Thus, output levels of the HD-10 are able to be increased in the middle and high frequency ranges. The purpose of this study was to investigate whether or not this consonant stressing function was effective in improving the auditory discrimination of Japanese consonants.

2. SUBJECTS AND METHODS

2.1. SUBJECTS

Fifteen patients with bilateral sensorineural hearing loss, who were using suitable analogue hearing aids fitted in our clinic, were tested. The level of hearing loss was moderate or severe in all cases. Figure 1 shows individual better ear air conduction audiograms of all patients. The age of the patients was 52·5 years on average (range 40–61 years), and the maximum speech discrimination score was 69·3% on average (range 40–82%).

2.2. METHODS

In the present study the patients' better ear was examined: (1) the speech discrimination scores for the HD-10 without the consonant stressing function were compared with those for the analogue hearing aid; (2) the speech discrimination scores for the HD-10 with the consonant stressing function at strong amplification were compared with those for the analogue hearing aid; (3) an investigation was conducted to determine which consonants showed improved speech discrimination when the consonant stressing function was used with the HD-10.

The electroacoustic characteristics were set the same for both hearing aids. The test sounds were generated from a speaker, placed 1 m in front of the subjects in a sound-shielded room. While the analogue hearing aids were worn behind the ear, the HD-10

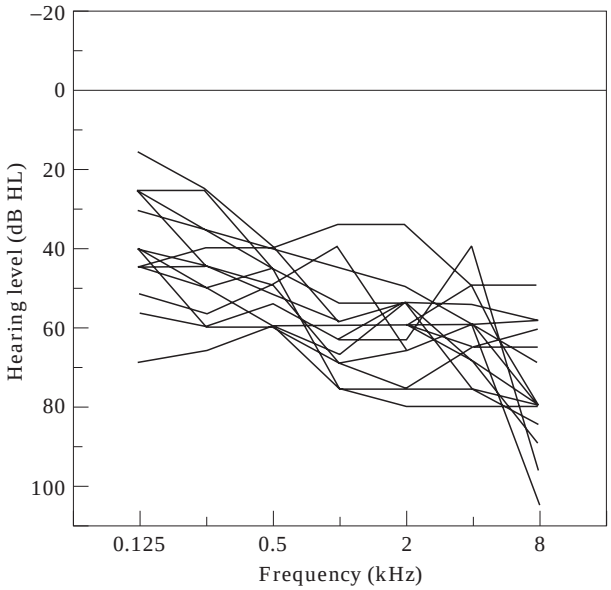

Figure 1. Better ears' audiograms in all patients.

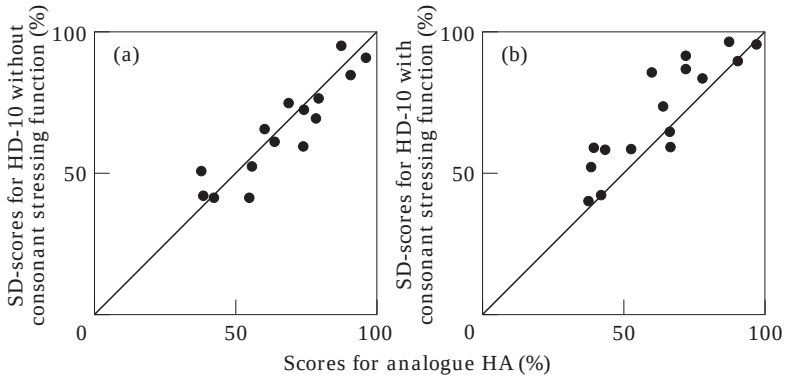

Figure 2. Comparison of speech discrimination (=SD) scores between the HD-10 and analogue hearing aids; (a) HD-10 without consonant stressing function; (b) HD-10 with consonant stressing function; HA, hearing aids. $N = 15$.

was worn on the patient's chest in order to approximate natural conditions. A DAT recorded monosyllable word list (TS-1) was used for the speech discrimination test and the intensity level of the test sound was set at 70 dB. The user's gain for both hearing aids was set at the most comfortable level.

3. RESULTS

3.1. COMPARISON OF SPEECH DISCRIMINATION SCORES

The speech discrimination scores for the HD-10 without the consonant stressing function were the same as those for analogue hearing aids and were worse in three cases (see Figure 2(a)). On the other hand, the speech discrimination scores for the HD-10 with the consonant stressing function showed approximately a 15% improvement over those for analogue hearing aids in eight cases, and remained at the same level in seven cases (see Figure 2(b)).

3.2. ANALYSIS OF DISCRIMINATION ABILITY OF CONSONANT SOUNDS

The Japanese consonants analysed were divided into three groups: (a) voiceless; (b) voiced and fricative; (c) nasal bound and semi-vowel. Figure 3(a) shows a comparison of the means of the scores between the HD-10 using the consonant stressing function and the analogue hearing aids for four voiceless consonant sounds. Among them, /s/ showed the most prominent improvement. Figure 3(b) shows the same comparison for two voiced and two fricative consonant sounds, in which case voiced consonant /b/ and fricative consonants /g/ and /z/ showed a significant improvement in favor of the HD-10. Figure 3(c) shows a comparison of the mean test scores for two nasal, one bound and two semi-vowel consonant sounds. In this comparison, bound sound /r/, semi-vowels /w/ and /y/ consonant sounds showed a significant improvement.

4. DISCUSSION

The fitting of digital hearing aids is currently being investigated throughout the world [3]. In Japan, the HD-10 is of particular interest because of its unique functions and special characteristics concerning Japanese consonant sounds.

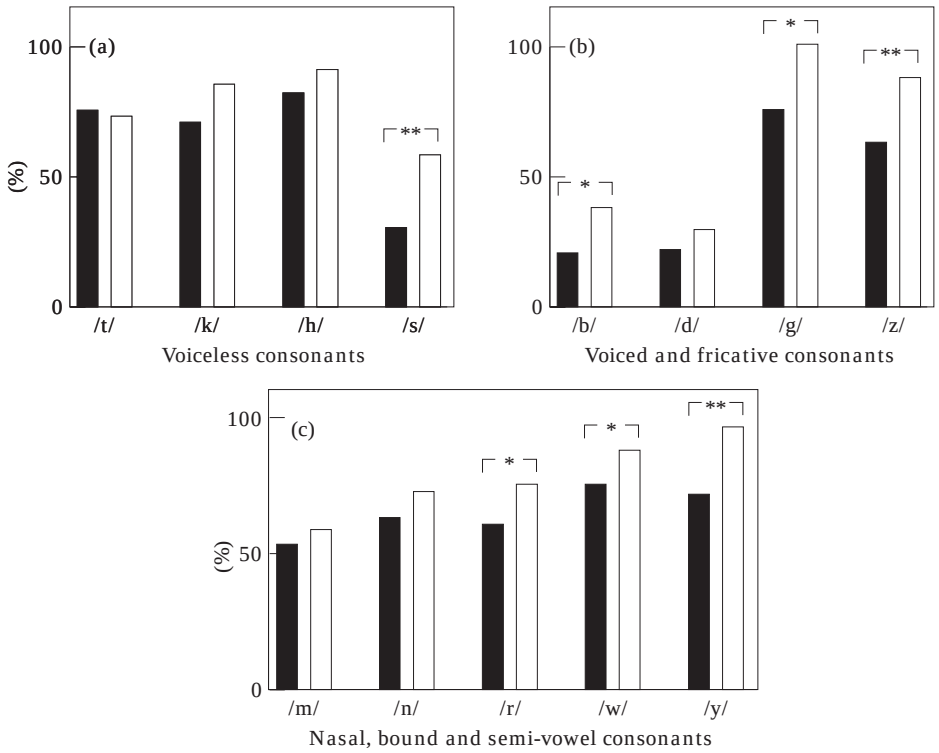

Figure 3. Comparison of means of speech discrimination scores between the HD-10 with consonant stressing function (□) and analogue hearing aids (■). The Japanese consonants are divided into three groups: voiceless (a), voiced and fricative (b) and nasal, bound and semi-vowel consonants (c). *, $p < 0{\cdot}05$; **, $p < 0{\cdot}001$. $N = 8$.

To increse output level, the HD-10 is designed with a consonant stressing function. This function allows an increase in output level up to 10–15 dB from the linear amplification level in the middle and high frequency ranges [1], when input level is under 40–60 dB. In general, speech discrimination is improved by emphasizing high frequency responses when using hearing aids [2]. However, when the input level is very high such as above 80 dB, the patients may be unable to use the hearing aid due to discomfort [4]. Furthermore, in both analogue hearing aids and digital hearing aids without the consonant stressing function, the possibility exists for speech discrimination to worsen when the non-linear amplification is compressed via the linear dynamic compression method [5]. The HD-10 was designed to compensate for these problems by non-linear amplification at middle and high frequency ranges.

When the consonant stressing function was not applied and the electroacoustic characteristics were set the same for both the HD-10 and the analogue hearing aids in the present study, the speech discrimination scores were almost the same for both aids. However, when testing the HD-10 with the consonant stressing function applied, the scores were better than those for analogue hearing aids. In particular, the discrimination of consonant sound showed an improvement of approximately 15% over the scores for analogue hearing aids. The digital hearing aids function thus allows more complex adjustments than do analogue hearing aids.

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