Auris Nasus Larynx 43 (2016) 269–280

Contents lists available at ScienceDirect

Auris Nasus Larynx

journal homepage: www.elsevier.com/locate/anl

Discrimination of Japanese monosyllables in patients with high-frequency hearing loss

Shotaro Karino [a,*], Shin-ichi Usami [b], Kozo Kumakawa [c], Haruo Takahashi [d], Tetsuya Tono [e], Yasushi Naito [f], Katsumi Doi [g], Ken Ito [h], Mitsuya Suzuki [i], Hideaki Sakata [j], Yutaka Takumi [b], Satoshi Iwasaki [k], Akinobu Kakigi [a], Tatsuya Yamasoba [a]

[a] *Department of Otolaryngology, University of Tokyo, Japan*
[b] *Department of Otolaryngology, Shinshu University, Japan*
[c] *Department of Otolaryngology, Toranomon Hospital, Japan*
[d] *Department of Otolaryngology – Head and Neck Surgery, Nagasaki University Graduate School of Biomedical Sciences, Japan*
[e] *Department of Otolaryngology, Miyazaki University, Japan*
[f] *Department of Otolaryngology, Kobe City Medical Center, Japan*
[g] *Department of Otolaryngology, Kinki University, Japan*
[h] *Department of Otolaryngology, Teikyo University, Japan*
[i] *Department of Otolaryngology, Sakura Medical Center, Toho University, Japan*
[j] *Department of Speech, Language and Hearing Therapy, Mejiro University, Japan*
[k] *Department of Hearing Implant Science, Shinshu University, Japan*

ARTICLE INFO

Article history:
Received 18 August 2015
Accepted 16 October 2015
Available online 19 November 2015

Keywords:
Speech discrimination
Monosyllable
Confusion matrix

ABSTRACT

Objective: To analyze the difficulty of discriminating Japanese nonsense monosyllables in each of several grades of high-frequency hearing loss and to evaluate the limitations of amplification.
Methods: We collected retrospective data on the discrimination of Japanese nonsense monosyllables by patients with three grades of high-frequency hearing loss who fulfilled or nearly fulfilled the Japanese criteria for EAS. Discrimination of the twenty monosyllables included in the 67-S speech audiometric test, which is approved by the Japan Audiological Society, was evaluated under quiet conditions.
Results: One hundred and five ears of ninety-one adults with high-frequency hearing loss were tested. We classified the ears according to hearing threshold at 1000 Hz; Group 1: <45 dB; Group 2: ≥45 dB and <70 dB; Group 3: ≥70 dB. Under the best conditions, the best speech discrimination scores were 72.3 ± 18.6% (mean ± SD, $N = 11$), 56.9 ± 19.9% ($N = 57$) and 38.1 ± 22.6% ($N = 37$) in Group 1, Group 2 and Group 3, respectively. For most of the monosyllables, discrimination score declined gradually as high-frequency hearing loss became more severe. The high incidence in the Japanese language of [k], an easy consonant to distinguish, may be an advantage for patients with high-frequency hearing loss who use hearing aids. By employing a new confusion matrix that displays consonants and the following vowels separately, we were able to reveal the interactions of those two components. We observed that discrimination of preceding nasal consonants and that of the following vowels were not independent in patients with high-frequency hearing loss.

* Corresponding author at: 7-3-1, Hongo, Bunkyo-ku, Tokyo 113-8655, Japan. Tel.: +81 3 5800 8665.
E-mail address: karinos-tky@umin.ac.jp (S. Karino).

http://dx.doi.org/10.1016/j.anl.2015.10.003

Conclusion: Our classification based on threshold at 1000 Hz was useful to predict the effectiveness and limitations of amplification in high-frequency hearing loss. Threshold at 1000 Hz can be an index enabling us to refine the indications of EAS for native Japanese speakers to maximize its effectiveness against high-frequency hearing loss.

1. Introduction

In ski-slope-type sensorineural hearing loss, acoustic amplification has limited effectiveness with regard to improving speech discrimination. This is due not simply to reduced audibility, i.e. elevated thresholds, but also to the negative effects of high presentation and a poorer-than-normal use of speech information in the frequency region with hearing loss [1,2]. Electric Acoustic Stimulation (EAS) appears to improve speech discrimination for ski-slope-type hearing loss. Indications for EAS should be established based on data that reveal speech perception in the native languages of partially deaf patients. If patients with residual hearing in the low-frequency region show good speech discrimination when test phonemes are presented at an adequately loud level, acoustic amplification remains valuable and electric stimulation by CI is not necessary for these patients.

Measuring speech discrimination is indispensable for predicting the effectiveness of EAS, regardless of the patient's native language. Extrapolating the audibility of pure tones is not a valid substitute for estimating speech discrimination. The present audiological criteria for EAS in Japan are: pure-tone hearing levels bilaterally at 65 dBHL for 125 Hz, 250 Hz, and 500 Hz; 80 dBHL at 2000 Hz; and 85 dBHL at 4000 and 8000 Hz; monosyllable scores with conventional hearing aids in quiet conditions under 60% in the best aided condition [3]. These criteria were established by slightly modifying those generated through a multicenter trial in the EU, based on the assumption that the acoustical properties of phonemes used in daily conversation in any language are within a common range of frequency and intensity. This assumption has not been completely verified, however. For example, the acoustical cues used for recognition of an identical consonant can be different among different languages in normal hearing listeners as well as patients with hearing impairment. Tyler and Moore reported consonant recognition in conventional CI patients with different native languages [4]. They used identical nonsense syllables with specific accents of French, German or English, and they demonstrated the differences in recognition among the three languages. Recognition of a sentence test is, of course, influenced by components specific to each language, such as accents. Furthermore, nonsense monosyllable tests among different languages cannot be simply compared. The mora structure in Japanese makes such comparisons particularly complicated.

Japanese phonemes, morae, and syllables are organized into a hierarchical structure [5]. The lowest phonological level is the phonemic level, representing consonants (C), semivowels (S), and vowels (V). The next level is the moraic level. The first mora consists of one of four possible combinations: a single vowel (isolated V, such as /a/, u/, and /o/), a consonant and a vowel (CV, such as /ta/), a semivowel and a vowel (SV, such as /wa/ and /jo/), or a consonant, a semivowel, and a vowel (CSV, such as /tja/). The second mora is represented by four special sounds: two consonants, represented by /N/ or /Q/, and two vowels, represented by /R/ (long vowel) and /J/ (dual vowels). CV-structured morae are called light syllables, meaning that each constitutes a single syllable as well as a single mora. The third and highest level in the hierarchical structure is the syllable level, which involves a combination of first and second morae. These combinations are termed heavy syllables.

Because the 67-S battery, which is approved by the Japan Audiological Society, consists of twenty light syllables (three isolated V, fifteen CV, and two SV), we exclusively discuss single meaningless morae (all of which are also monosyllables). Consonants in this Japanese-language test are always followed by vowels, and this can be an effective cue for high-frequency hearing loss patients, though it is not usually used by individuals with normal hearing. Because these Japanese monosyllables do not have the same phonological structure as monosyllables in other languages, any comparison with monosyllable tests in other languages requires careful interpretation. For example, the German monosyllable test (Freiburger Einsilbertest) [6] consists of meaningful words which do not always have a simple CV structure. Japanese and German patients with high-frequency hearing loss can employ different cues to recognize identical phonemes, even if they share identical audiometric thresholds. Therefore, detailed analyses of the ways in which each Japanese monosyllable is discriminated can suggest helpful modifications to the indication criteria for EAS for high-frequency hearing loss patients who speak Japanese.

The purpose of this study is to collect data on the difficulty of discriminating each Japanese nonsense monosyllable in each of several grades of high-frequency hearing loss. There have been few previous reports on this subject [7]. We investigated speech discrimination in patients with high-frequency hearing loss who precisely or nearly fulfill the Japanese criteria for EAS, and generated a confusion matrix of Japanese monosyllables.

2. Methods

We conducted a retrospective review of medical records from ten hospitals enrolled in our project in which hearing evaluations in patients with high-tone sensorineural hearing loss were conducted using twenty Japanese monosyllables.

91 adults with high-frequency hearing loss (27–90 yo; mean 64 yo; 48 males and 43 females) were selected as candidates. Each ear fulfilled the following three criteria with respect to thresholds in pure tone audiometry: