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Language-specific strategy for programming hearing aids — A double-blind randomized controlled crossover study

Nozomu Matsumoto [a,*], Nobuyoshi Suzuki [b], Satoshi Iwasaki [b], Kazuha Ishikawa [a], Hiroki Tsukiji [a], Yoshie Higashino [a], Tomoko Tabuki [a], Takashi Nakagawa [a]

[a] Department of Otorhinolaryngology, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan
[b] Department of Otolaryngology, International University of Health and Welfare Mita Hospital, Tokyo, Japan

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ABSTRACT

Objective: Voice-aligned compression (VAC) is a method used in Oticon's hearing aids to provide more comfortable hearing without sacrificing speech discrimination. The complex, non-linear compression curve for the VAC strategy is designed based on the frequency profile of certain spoken Western languages. We hypothesized that hearing aids could be further customized for Japanese-speaking users by modifying the compression curve using the frequency profile of spoken Japanese.
Methods: A double-blind randomized controlled crossover study was performed to determine whether or not Oticon's modified amplification strategy (VAC-J) provides subjectively preferable hearing aids for Japanese-speaking hearing aid users compared to the same company's original amplification strategy (VAC). The participants were randomized to two groups. The VAC-first group received a pair of hearing aids programmed using the VAC strategy and wore them for three weeks, and then received a pair of hearing aids programmed using VAC-J strategy and wore them for three weeks. The VAC-J-first group underwent the same study, but they received hearing aids in the reverse sequence. A Speech, Spatial and Qualities (SSQ) questionnaire was administered before beginning to use the hearing aids, at the end of using the first pair of hearing aids, and at the end of using the second pair of hearing aids.
Results: Twenty-five participants that met the inclusion/exclusion criteria from January 1 to October 31, 2016, were randomized to two groups. Twenty-two participants completed the study. There were no statistically significant differences in the increment of SSQ scores between the participants when using the VAC- or the VAC-J-programmed hearing aids. However, participants preferred the VAC-J strategy to the VAC strategy at the end of the study, and this difference was statistically significant.
Conclusion: Japanese-speaking hearing aid users preferred using hearing aids that were fitted with the VAC-J strategy. Our results show that the VAC strategy can be adjusted to the frequency profile of different languages and that participants expressed their subjective preference more clearly than was reflected in the SSQ scores. A similar language-specific strategy may improve user's satisfaction while using hearing devices, and this concept may be extended to implantable hearing devices.
Clinical research registration number: R000023191.

* Corresponding author at: Department of Otorhinolaryngology, Graduate School of Medical Sciences, Kyushu University, 3-1-1 Maidashi, Higashi-ku, Fukuoka 812-8582, Japan.
E-mail address: matunozo@med.kyushu-u.ac.jp (N. Matsumoto).

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1. Introduction

Hearing loss is the most prevalent disability worldwide and is now known as a risk factor for dementia [1,2]. Therefore, more active intervention to treat hearing loss may help patients improve not only their hearing but also their cognitive status. For example, cochlear implant recipients >65 years of age showed improvement in cognitive test results after using the cochlear implants [3]. Furthermore, it was determined that if an intervention can delay the onset of dementia for 1 year, the overall population of dementia patients in the year 2050 will be reduced by 9 million [3]. Japan, which is a rapidly aging society equipped with near-universal healthcare insurance, will likely be one of the earliest test cases for evaluating whether or not such intervention against hearing loss does indeed improve the overall cognitive status of a society. However, Japan has one of the lowest ratios of hearing-impaired people using hearing aids; the adoption rate of hearing aids in Japan is 14.1%, which is lower than that of other developed countries such as Norway (42.5%), the UK (41.1%) and the US (24.6%) [4]. The same survey cited hearing aids being "uncomfortable" as among the top 10 reasons that hearing aid owners decided not to wear them. This is consistent with the well-known clinical experience that many patients simply "dislike" hearing aids even if hearing evaluation indicate benefit of wearing hearing aids. Therefore, efforts to improve patient's subjective evaluation of hearing devices is as important as other "objective" hearing test results to improve the adoption rate.

At present, hearing aids are programmed according to the users' residual hearing level under the assumption that retrieving "normal" hearing results in the greatest benefit. However, such "ideal" fitting of hearing aids is often perceived as creating "too strong, unacceptably ear-piercing" sounds, thereby reducing user satisfaction. Oticon A/S (Smørum, Denmark) developed a unique amplification strategy known as voice-aligned compression (VAC), which is based on the perceived loudness of the spoken language [5,6]. Hearing aids that are programmed using the VAC strategy focus more on the specific range of frequency and intensity that are necessary to understand the spoken language. The VAC-programmed hearing aids are usually perceived as "softer" hearing aids by users and may improve the comfort of sounds without sacrificing the overall hearing [7].

However, the VAC strategy was developed using the frequency profiles of Western languages. This has prompted the hypothesis that similar strategies using frequency profiles of other languages may provide additional benefit for specific language users, as frequency profiles can differ significantly among languages [8]. The Japanese language contained more energy than Western languages at high frequency range (>4 kHz) especially when spoken loudly, requiring less amplification in the same frequency range and intensity (unpublished observation under review). On the other hand, the Japanese language required more amplification in low frequency range (0.5–1 kHz) when spoken in soft to moderate intensity (unpublished observation under review). Therefore, the Japanese version of the VAC, which we subsequently refer to as the VAC-J strategy, was developed based on the frequency profiles of spoken Japanese. Objectively, the VAC-J was not inferior to the VAC strategy in terms of monosyllable speech recognition (unpublished observation under review). However, our main clinical question concerned the subjective preference, wondering whether or not users favor the VAC-J strategy to the VAC strategy, because the subjective preference is the last and the key factor that patient ultimately decide whether or not to wear the hearing aids. Therefore, we investigated whether or not Japanese-speaking hearing aid users prefer the Japanese-specific amplification strategy (VAC-J) to the original amplification strategy of the same concept (VAC).

2. Materials and methods

2.1. Participant selection

Participants who met the inclusion and exclusion criteria (Table 1) from January 1 to October 31, 2016 were recruited. Those who agreed to join the study provided their written informed consent and were registered. The institutional ethical review board of Kyushu University and the internal review board of the International University of Health and Welfare Mita Hospital approved our study.

2.2. Study design

A double-blind randomized controlled crossover study was designed as shown in Fig. 1. The results of the pure tone audiometry and monosyllable speech recognition tests of the registered participants were sent to the remote hearing aid center. The hearing aid center randomized the participants into one of two groups. The VAC-first group received a pair of hearing aids programmed using the VAC strategy (currently distributed as the "VAC+" strategy) and wore them for three

Table 1
Criteria for inclusion and exclusion.

Inclusion (must meet all of the below)	Exclusion (excluded if any of the below is true)
1. Age ≥ 20 years	1. Poor overall health
2. Able to understand instructions and make decisions	2. Hearing loss due to bilateral acoustic neuroma
3. Native Japanese speaker	3. Hearing loss due to intracranial surgery
4. Bilateral hearing loss with ≥45 dB hearing threshold in 3-frequency average in both ears	4. Hearing loss due to cranial trauma
5. Maximum speech recognition ≥ 50% at least in 1 ear	5. Scheduled to receive chemotherapy that includes ototoxic anticancer drugs during the research period
6. Speech recognition at 50 dB ≤ 50% at least in 1 ear	

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