Preferred Hearing Aid Gain in Everyday Environments

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ABSTRACT

Thirty-three hearing-impaired individuals were each fitted with three hearing aids. The instruments conformed to three frequency-gain prescriptions, differing by a total of 8 dB/octave, with the middle prescription derived using the MSU version 3.0 procedure. The subjects were divided into three matched groups of eleven. Each group used the fitted hearing aids in one of three everyday listening environments representing quiet, reverberant, and noisy situations, respectively. In each listening environment, preferred hearing aid gain for conversationally produced speech was measured in each hearing aid condition for each subject. Preferred gain in daily listening situations was compared to prescribed gain. Results indicated that: (1) preferred gain averaged across all three environments was about equal to prescribed gain, (2) mean preferred gain in each separate environment was substantially different from the prescribed level, (3) volume control adjustments of about ±8 dB relative to the prescribed level would be necessary to accommodate the preferred gain settings of the typical hearing aid wearer in daily life. Guidelines are presented for establishing recommended volume control settings for hearing aid users who may be unable to set the volume control independently. (Ear Hear 12 2:123-126)

PRESCRIPTIVE PROCEDURES FOR DETERMIN-ING hearing aid frequency-gain characteristics incorporate specifications for both frequency response slope and overall gain. However, differences in slope have attracted more attention from researchers than have differences in overall gain (e.g., Byrne, 1987). It has traditionally been assumed that it is more important to prescribe the appropriate slope than to prescribe the appropriate overall gain because the hearing aid wearer can adjust the volume control to produce the optimal gain level. However, as clinicians can attest, many

hearing aid wearers are not confident about their own ability to select appropriate volume settings. These individuals tend to rely on the dispenser's specific recommendations for volume control adjustment. If these recommendations are inappropriate, the outcome of the hearing aid fitting is in jeopardy. Thus, it can be argued that a fully adequate frequency gain prescription should encompass appropriate specifications for both slope and gain.

As demonstrated by Humes (1986), prescriptions that specify greater gain often appear to be superior because predicted speech intelligibility is greater than for lower gain prescriptions. However, several studies of gain used in everyday life have noted that average preferred gain settings are considerably lower than those specified by many prescriptive procedures (Clasen, Vesterager, & Parving, 1987; Leijon, Eriksson-Mangold, & Bech-Karlsen, 1984; Mukundan & Malini, 1988). Hence, despite the theoretical advantages of higher gain prescriptions, there is evidence to suggest that they may not find acceptance in daily use, at least among persons having mild to moderately severe hearing loss.

This note reports a study of gain levels preferred by hearing aid wearers in daily listening. Preferred gain was measured in three typical listening environments for each of three hearing aid conditions differing in frequency response slopes. The main research questions were as follows:

1. What is the effect of frequency response slope on preferred gain?
2. How closely does preferred gain correspond to prescribed gain?
3. What is the effect of listening environment on preferred gain?

It was anticipated that the data would furnish guidelines for specific recommendations about hearing aid gain settings in daily life.

METHOD

The data reported here were collected in the course of a study of hearing aid benefit that is fully reported in a companion article (Cox & Alexander, 1991). Details of subjects, hearing aids, environments, and stimuli are given in that paper. Consequently, relatively brief descriptions are given here.

Subjects Three matched groups of 11 subjects each served

in the study. All had bilateral, mild to moderately severe, sensorineural hearing impairment. They were mostly elderly and most were experienced hearing aid wearers. Each group served in only one of the listening environments.

Hearing Aids Hearing aid fittings were accomplished in a double walled, sound treated room. Each subject was fitted with three over the ear hearing aids, each configured to match a different prescription. The three prescriptions differed in slope by a total of 8 dB/octave. The middle prescription was determined using the MSU version 3.0 prescriptive procedure (Cox, 1988). For each individual, the hearing aid chosen to implement the MSU prescription is referred to as HAO. The second prescription differed from HAO by −4 dB/octave. This more negative slope hearing aid is designated HAN. The third prescription differed from HAO by +4 dB/octave. This more positive slope hearing aid is termed HAP. In an attempt to maintain equal loudness among the three prescriptions despite their differing slope, gain was adjusted for the HAN and HAP prescriptions so that the average gain at 1000, 1600, and 2500 Hz was equal to the analogous average for the HAO prescription. This strategy was derived from data reported by McDaniel (1988).

Environments Three typical environments were used. Environment A represented a communication situation in which speech is at normal or casual conversational level, visual cues are fully available, and background noise and reverberation are relatively low. Examples of environment A include face to face conversation in a typical living room or quiet office. Environment B represented a communication situation in which external environmental noise is low but speech cues are reduced because of reverberation, low speech intensity, or limited or absent visual cues. Examples of environment B include listening as an audience member to a lecture delivered in an unamplified classroom, communicating over a distance, and listening to someone whose face is not visible. Environment C represented a communication situation where external environmental noise is relatively high, speech levels are somewhat raised, and visual cues are available. Examples of environment C include face to face communication at a social event with numerous people present and communication with a clerk in a busy store. In summary, environments A, B, and C represented typical quiet, reverberant, and noisy listening situations, respectively.

Stimuli While choosing their preferred volume control settings, subjects listened to passages of connected speech presented at a level appropriate for the listening environment. The passages were drawn from the Connected Speech Test (Cox, Alexander, Gilmore, & Pusakulich, 1989) and were presented without visual cues. The test's multitalker babble served as the background noise in each environment.

Procedure During hearing aid fittings for each subject, the gains of the experimental hearing aids were adjusted according to the amount called for by the MSU prescription (for HAO) and amounts estimated to produce amplified speech that was equal in loudness to that produced by the MSU prescription (for HAN and HAP). After each fitting was verified using a probe microphone procedure, the 2 cm³ coupler gain was measured. These data are referred to as the prescribed gain.

Later, while listening to speech in the everday environments, subjects adjusted each hearing aid to produce their preferred listening level in that environment. These adjustments were performed using a bracketing procedure and continued adjustment was permitted over a period of at least 15 min. Subsequently, 2 cm³ coupler gain was measured for

each hearing aid condition at the chosen volume setting. These data are referred to as the preferred gain.

RESULTS

Figure 1 illustrates the average 2 cm³ coupler gain of each of the three hearing aid conditions as they were adjusted during the fitting procedure (prescribed gain). Data for all subjects are included in this figure. The slope differences among the three instruments are readily apparent, as is the fact that gain was equated across instruments in the 1600 Hz frequency region.

Effect of Frequency Response Slopes on Preferred Gain

To explore the effects of frequency response slopes on preferred gain in different listening environments, the gain adjustments chosen by the subjects were compared to those made in the original fitting procedure as illustrated in Figure 1.

The mean 2 cm³ coupler gain curves in each hearing aid condition, after adjustment to produce preferred listening levels, are given in the three panels of Figure 2. Each panel depicts data for one listening environment. In all three environments, the relationships among the three frequency responses at the preferred gain settings were quite similar to the prescribed relationship in Figure 1. However, the pattern was less clearly produced in environment B than in the two other environments.

Preferred Gain Compared to Prescribed Gain

Although Figure 2 shows the preferred relationships among the three frequency responses in the tested environments, the overall gain used in each condition in each environment, and its relationship to the prescribed gain, is not readily apparent. To examine this issue, the average gain at six frequencies from 500 Hz to 4 kHz was computed for each hearing aid condition, both in
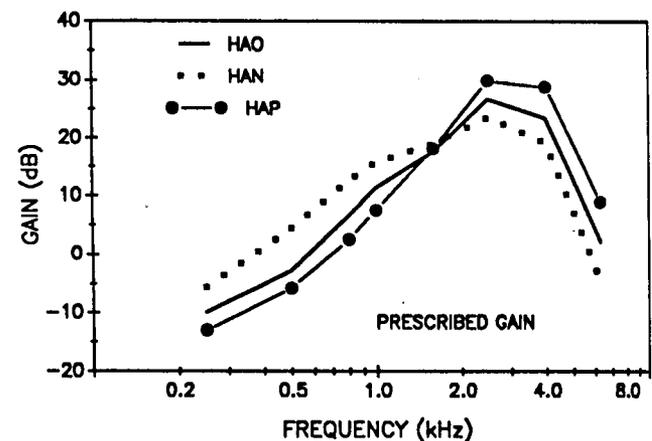

Figure 1. Average 2 cm³ coupler gain of each of the three hearing aid conditions (HAO, HAN, and HAP) as they were adjusted during the fitting procedure. Data for all three subject groups are included in this figure.
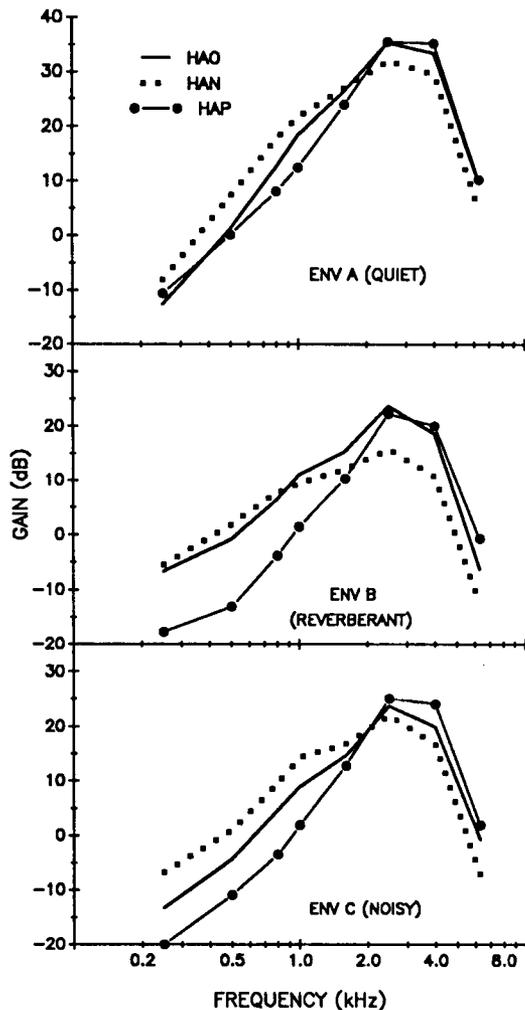
Figure 2. Average 2 cm³ coupler gain curves of the three hearing aid conditions in each environment after adjustment to produce preferred listening levels.

Figure 3. Differences between the mean prescribed gain and the mean preferred gain for each hearing aid condition in each environment. Positive values indicate that preferred gain was greater than prescribed gain when the hearing aid was used in the everyday environment. Negative values indicate that the preferred gain in the everyday environment was less than the prescribed gain.

the original fitting (prescribed gain) and after adjustment to produce the preferred listening level in the tested environment (preferred gain). The preferred overall gain averaged across all environments was 13.7 dB. This was not significantly different from the prescribed overall gain of 14.3 dB [$F(1,30) = 0.28$, $p > 0.05$].

Differences between the mean prescribed gain across all subjects and the mean preferred gain in each environment were then determined. Results are shown in Figure 3. In this figure, positive values indicate that the hearing aid's mean preferred gain was greater than the mean prescribed gain when the instrument was used in the real environment. Negative values indicate that the mean preferred gain in the real environment was less than the mean prescribed gain. Figure 3 reveals that, for all three hearing aid conditions, the average gain was increased in environment A relative to the prescribed level. In environments B and C, on the other
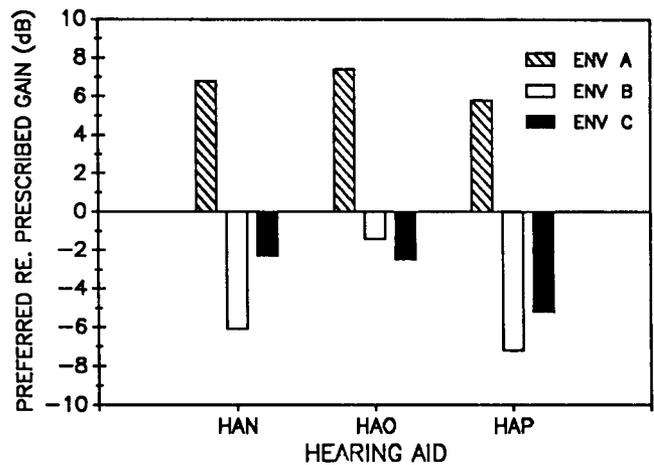
hand, the preferred gain for all three hearing aid conditions was less than the prescribed level. On average, preferred gain settings depended rather strongly on listening environment.

The statistical significance of these data, and the possible effects of frequency response slope on preferred gain levels, were explored by subjecting the mean preferred gain data to a repeated measures analysis of variance with one between-analysis subjects factor (environment) and one within-subject factor (frequency response slope). The main effect of environment was significant [$F(2,30) = 5.04$, $p = 0.01$], as was the effect of frequency response slope [$F(2,60) = 10.8$, $p < 0.01$]. The interaction was not significant. Post hoc testing using the Student-Neumann-Keuls procedure ($\alpha = 0.05$) revealed that the average amount of gain preferred in environment A (20.9 dB) was significantly greater than that preferred in environments B and C (9.4 and 10.9 dB, respectively) but environments B and C did not differ from each other in mean preferred gain setting. Furthermore, the mean preferred gain (across all experiments) associated with HAP, the positive slope, hearing aid condition (11.2 dB), was significantly less than the mean preferred gains associated with HAO (14.9 dB) and HAN (15.2 dB). However, preferred gains for HAO and HAN did not differ significantly from each other.

DISCUSSION

Comparison of the panels of Figure 2 suggests that the loudness-based approach used to equate the three prescriptions was predictive of their preferred gain relationship in the real life setting, especially in the two nonreverberant environments. These data illustrate that increased gain in one frequency region can be achieved

only at the expense of decreased gain in another frequency region.

The mean preferred gain averaged across all environments was about the same as the mean prescribed gain in this study. Because the MSU procedure prescribes less gain than most other prescriptions (Skinner, 1988), this outcome is consistent with previously reported data suggesting that, for elderly listeners with mild to moderately severe sensorineural impairments, required gain in daily life may be lower than many prescriptions suggest. It is important to note that these results should not be generalized beyond this group.

Although the prescribed gain was a good estimate of the preferred gain across all environments, it was not an accurate estimate of the preferred gain in any specific environment. This outcome clearly supports many anecdotal reports by hearing aid wearers about their need to adjust the volume control of their instrument in different daily life situations. Moreover, the data suggest that, for the average hearing aid wearer, the range of available volume adjustments (without feedback or distortion) should encompass about ±8 dB relative to the prescribed gain.

The data also suggest a possible strategy for counseling hearing aid wearers who are unable, or unwilling, to appropriately vary their volume control settings in daily life. For these individuals, it would be reasonable to establish two recommended volume control settings approximately 10 to 12 dB apart: the first (5–6 dB higher than MSU prescribed gain) for quiet environments, and the second (5–6 dB less than MSU prescribed gain) for noisy and reverberant environments.

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