J Am Acad Audiol 11: 429–437 (2000)

Hearing Aid Benefit in Patients with High-Frequency Hearing Loss

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Abstract

Patients with hearing loss limited to frequencies above 2 kHz are often considered borderline candidates for hearing aids. In this study, we used the Profile of Hearing Aid Benefit to access 134 patients' perceived benefit with a variety of linear hearing aids, some more capable than others at achieving prescribed frequency gain targets. We also sought to explore various audiologic and subject factors that might have led patients to report different degrees of success or failure with their hearing aids. Results demonstrate that subjects with hearing loss limited to frequencies above 2 kHz benefit significantly from amplification. However, the amount of benefit reported is mostly unrelated to the hearing aid gain and frequency response. Of numerous audiologic and demographic factors explored in the present study, the number of hours of hearing aid use per day turned out to be the most important single factor that was significantly related to the amount of reported hearing aid benefit. However, the predictive value of knowing how many hours per day subjects wore their aids, or any other combination of factors explored, was quite limited and only accounted for a small amount of the variability observed in user benefit.

Key Words: Gain and frequency response, hearing aid benefit, hearing questionnaire, prescriptive formula

Abbreviations: AASC = Army Audiology and Speech Center, ANOVA = analysis of variance, AR = aural rehabilitation, AV = PHAB subscale Aversiveness, BN = PHAB subscale Background Noise, BTE = behind-the-ear hearing aid, DS = PHAB subscale Distortion, EC = PHAB subscale Ease of Communication, FT = PHAB subscale Familiar Talker, ITE = in-the-ear hearing aid, NAL-R = National Acoustic Laboratories–Revised presciptive hearing aid fitting formula, PHAB = Profile of Hearing Aid Benefit, RC = PHAB subscale Reduced Cues, RV = PHAB subscale Reverberation

Subjects with normal hearing through 2000 Hz and measurable hearing loss at higher frequencies are often considered borderline candidates for hearing aids (Mueller et al, 1991; Van Vliet, 1999). However, clinical experience suggests that significant communication problems in background noise and reverberation are often experienced by these patients. Annianson (1974) demonstrated that significant speech recognition problems can occur even if the hearing loss is restricted to the 3000- to 4000-Hz region. Similarly, Smoorenburg (1992) reported that hearing handicap can become noticeable to the listener in noisy environments when the pure-tone average of 2000 Hz and 4000 Hz exceeds 30 dB.

Until fairly recently, providing high-frequency amplification for this population has been challenging because of technical limitations of the instruments. In the past, the hearing aid of choice was typically a behind-the-ear (BTE), high-frequency-emphasis instrument coupled to an open earmold. It was assumed that greater high-frequency emphasis and less occlusion effect would be achieved with this arrangement than with the more occluding in-the-ear (ITE) devices (Grover and Martin, 1979; Cox and Alexander, 1983; Killion, 1988). However, in an attempt to achieve adequate high-frequency gain, the frequency response of these hearing aid fittings was often characterized

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by too much mid-frequency gain and not enough high-frequency gain (Humes and Hackett, 1990; Bratt and Sammeth, 1991).

Given that current hearing aid technology permits highly selective amplification for this population so that the gain and frequency response characteristics can more closely match a prescriptive target (Sammeth et al, 1993), it is important to determine whether precise spectrum shaping is required for optimizing speech intelligibility and subjective benefit (for this population) once audibility has been taken into account.

One purpose of the present study was to determine whether reasonable deviations from target gain values, as might be expected from different hearing aid instruments, affect perceived benefit from amplification.[1] A second purpose was to explore the possible influence of audiologic factors, such as degree and slope of the high-frequency hearing loss, and demographic factors, such as age, aural rehabilitation program, and hours of hearing aid use, on perceived benefit for this population.

METHOD

Subjects

A total of 258 patients with high-frequency hearing loss were identified as potential subjects from clinic records at the Army Audiology and Speech Center (AASC), Walter Reed Army Medical Center. Initial subject selection was based on the following criteria: (1) pure-tone thresholds no greater than 20 dB HL for frequencies 250 Hz through 2000 Hz and a pure-tone average of at least 25 dB HL for frequencies at 3000 Hz and 4000 Hz (re: ANSI, 1989); (2) relatively symmetric hearing losses (i.e., no more than a 15-dB difference in thresholds at any frequency); (3) no history of chronic middle ear disease or retrocochlear signs; (4) word recognition scores in quiet between 80 percent and 100 percent; and (5) use of binaural amplification for at least 6 months prior to participation in the study. All of the 258 patients were male and had received hearing aids as an entitlement for military service. One hundred sixty-four (64%) were on active duty and 94 (36%) were retired from military service at the time they received their hearing aids.

Procedures

The Profile of Hearing Aid Benefit (PHAB) was used (Cox and Gilmore, 1990; Cox and Rivera, 1992) to evaluate unaided and aided performance. The PHAB consists of 66 items that describe performance in a variety of communication situations that can be problematic to hearing-impaired persons (e.g., listening in background noise or in reverberant environments such as a classroom). The patient rates his/her agreement with each statement using a 7-point scale describing the percentage of time that a statement is true: always (99%), almost always (87%), generally (75%), half-the-time (50%), occasionally (25%), seldom (12%), and never (1%). Each item is rated twice, first "without my hearing aid" (unaided) and then "with my hearing aid" (aided). Benefit is defined as the difference between the unaided and aided responses (in percent). The PHAB is divided into four scales and seven subscales that address benefit from amplification in different listening environments. Five of the subscales—Familiar Talkers (FT), Ease of Communication (EC), Reverberation (RV), Reduced Cues (RC), Background Noise (BN)—address speech communication, whereas the remaining two subscales—Aversiveness of Sounds (AV) and Distortion of Sounds (DS)—address perception of environmental sounds. The PHAB also contains questions regarding number of hours of hearing aid use per day, total number of years of hearing aid use, and employment status (full-time employed, part-time employed, or not working outside of the home).

The PHAB questionnaire was mailed to each of the 258 patients. Of the 258 questionnaires mailed, 110 were never returned and 14 were returned incomplete. The remaining 134 patients formed the cohort for this study. The mean age of the subjects was 56.7 years old (range = 22–82 years). The mean audiogram for the entire group is shown in Figure 1.

All subjects reported a history of some noise exposure and had attended one of two aural rehabilitation (AR) programs provided at the AASC. The first program, attended by 57 subjects, was a 3½-day residential program that emphasized the care and use of the hearing

[1]A recent paper by Byrne (1996) addressed a similar question for newer, mainly nonlinear, types of hearing aids for which an attempt is made to restore normal loudness growth functions. For both older (matching to a prescribed target) and newer fitting strategies (restoration of normal loudness growth functions), the question is whether a precise match to some prescribed gain function is necessary for maximizing hearing-aid benefit, once audibility has been taken into account.

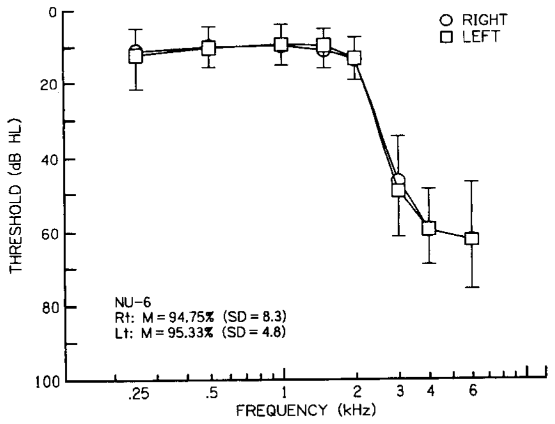

Figure 1 Mean audiogram for the group of 134 subjects. Error bars are ± 1 SD. NU-6 = Northwestern University Auditory Test No. 6.

aids, anatomy and physiology of the ear, audiogram interpretation, hearing conservation, and communication strategies (hereafter, long AR). The second program, attended by 77 subjects, was a 2-hour hearing aid orientation that addressed care and use of the hearing aids as well as some communication strategies (hereafter, short AR). The subjects who attended the long AR program were significantly younger ($\bar{x}$ = 49.8) than those who attended the short AR program ($\bar{x}$ = 61.9) and were primarily active duty personnel as opposed to retirees.

The subjects had been fit prior to the onset of the study with one of six hearing aids. All of the hearing aids were analog and linear and used peak clipping for output limiting.[2] Major differences among the hearing aids included directional, omnidirectional, and high-frequency emphasis microphones and Class D versus Class A amplifiers. Eighty-four percent of the subjects were fit with ITE instruments and the remaining (16%) with BTE hearing aids. For the BTE users, earmolds were nonoccluding, "CROS" style. ITE hearing aids were vented appropriately. Of the total ITE hearing fittings, 28 percent were the full concha shell ITEs, 33 percent were low profile, 22 percent were half concha, and 1 percent were canal (in-the-canal [ITC]) style. Saturation sound pressure level 90 for the hearing aids was appropriate for the degree of hearing loss and varied from 102 dB SPL to 115 dB SPL. At the onset of the study, the number of months of hearing aid use by individual subjects ranged from 8 months to 42 months (mean of 21 months).

[2]Although it is becoming increasingly more common to fit nonlinear hearing aids as compared to linear aids, the latter are still being manufactured and dispensed. In 1998, a hearing instrument market survey (Skafte, 1999) indicated that 26 percent of all hearing instruments sold in 1998 were linear, nonprogrammable hearing aids. Skafte did not delineate the number of programmable or digital signal processing devices that may have been fit as linear instruments.

RESULTS

Based on clinical experience prior to initiation of this study, two of the hearing aids used were thought to provide more exact matches to prescriptive target values than the other devices. Seventy-four of the 134 study subjects (group 1) had been fit with these two instruments. The remaining 60 subjects (group 2) had been fit with five other types of hearing aids that were suspected of being less capable of providing precise match to target gain values. Verification of the degree of match to prescriptive target was performed by comparing insertion gain with target values specified by the National Acoustic Laboratories-Revised (NAL-R) prescriptive formula (Byrne and Dillon, 1986). The gain control on the hearing aids was adjusted to approximate the NAL target as best possible. Insertion gain responses were measured on either a Frye Electronics Fonix 6500 Hearing Aid Test System or a Rastronics Frequency Response Analyzer CCI-10/3. For group 1, frequency responses generally matched NAL target gain values within 4 dB at test frequencies from 0.5 to 4 kHz for both ears. For group 2, frequency responses deviated from NAL targets by more than 6 dB at 1.5 and 2 kHz. The average deviations from NAL target values for right (top) and left (bottom) ears for the two groups are depicted in Figure 2.

Other than differences in achieved hearing-aid gain, several other demographic factors for the two groups were mostly similar. The mean age was 56.3 (SD = 12.5) years for group 1 and 57.3 (SD = 13.3) years for group 2. The pure-tone average hearing loss measured at 3 and 4 kHz (averaged across ears) was 54.7 (SD = 9.3) dB for group 1 and 52.6 (SD = 7.7) dB for group 2. The average slope of the hearing loss for frequencies between 2 to 4 kHz (averaged across ears) was 48.6 dB/octave (SD = 10.1) for group 1 and 45.0 dB/octave (SD = 9.7) for group 2. The length of time of hearing aid use was somewhat less for group 1 (16.8 months, SD = 6.1) than for group 2 (26.1 months, SD = 7.9).

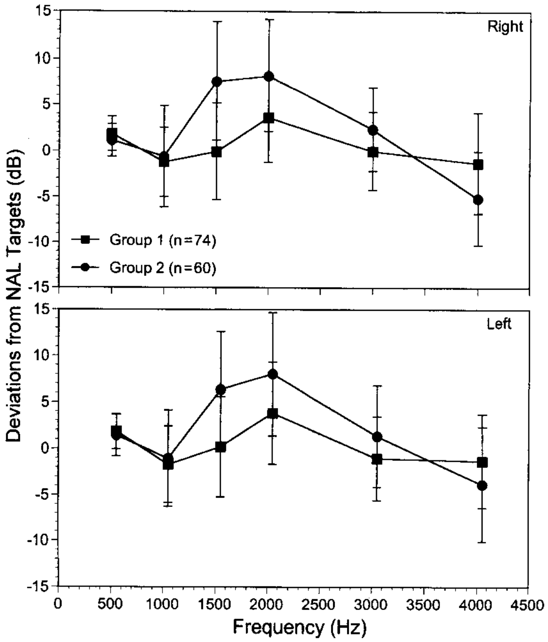

Figure 2 Average deviation between achieved insertion gain and National Acoustic Laboratories' prescriptive targets as a function of subject group. Group 1 = squares, group 2 = circles. Top panel = right ear, bottom panel = left ear. Error bars are ± 1 SD.

To access whether the deviations from NAL target values were significantly different for the two groups, the average rms deviation for left and right ears combined at 0.5, 1, 1.5, 2, 3, and 4 kHz was computed and subjected to an analysis of variance (ANOVA). The ANOVA showed that the groups differed with respect to NAL target values with group 1 having significantly smaller deviations for both the left ear [$F(1, 131) = 22.33$, $p = .00001$] and the right ear [$F(1, 130) = 30.82$, $p < .00001$]. Paired t-tests using Dunn-Sidak adjustments for multiple comparisons revealed that the two groups differed significantly at 1500, 2000, 3000, and 4000 Hz for the right ear, whereas significant differences between groups were observed at 1500, 2000, and 3000 Hz for the left ear. In general, the hearing aid fits for group 2 had significantly greater gain in the mid frequencies (1500–3000 Hz) and significantly less gain at high frequencies (4000 Hz and above) when compared to group 1.

A major question of this study was whether the significant group difference in deviation from prescribed hearing-aid gain targets translated into differences in perceived hearing aid benefit. This was accomplished by comparing PHAB benefit scores for the seven subscales between groups.

Figure 3 shows that the amount of benefit reported by both groups was quite similar for all seven PHAB subscales. A repeated-measures ANOVA with the seven PHAB subscales as a within-subject factor and subject group as a between-subject factor revealed no significant difference in the amount of benefit reported for the two groups [$F(1, 132) = 0.15$, $p = .70$] and no interaction between group and subscale [$F(6, 792) = 0.77$, $p = .59$].

Given their statistical equivalence in perceived benefit for the two groups of subjects, the data were pooled into one group for all subsequent analyses. To determine the significance of perceived benefit scores, multiple one-sample t-tests were performed with the null hypothesis being zero benefit. As a protection for multiple testing, the Dunn-Sidak adjustment was used to correct probabilities. Significant benefit was observed for all of the subscales dealing with speech communication ($t_{EC} = 12.9$, $p < .00001$; $t_{FT} = 13.6$, $p < .00001$; $t_{RV} = 16.6$, $p < .00001$; $t_{RC} = 17.4$, $p < .00001$; and $t_{BN} = 15.6$, $p < .00001$). As expected, subjects reported that their hearing aids had a significant deleterious effect for the subscale dealing with perception of adverse environmental sounds ($t_{AV} = -13.4$, $p < .00001$). There was no benefit reported for the subscale dealing with the distortion of sounds ($t_{DS} = 1.1$, $p = .9$), even though subjects reported significant

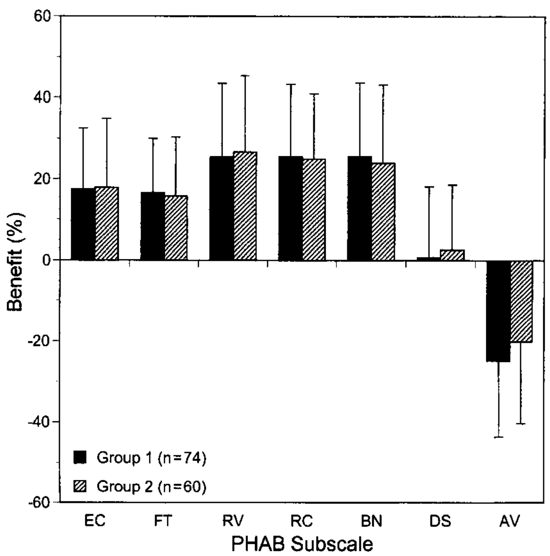

Figure 3 Profile of Hearing Aid Benefit (PHAB) scores as a function of subject group. Group 1 = solid bars, group 2 = striped bars. EC = Ease of Communication, FT = Familiar Talker, RV = Reverberation, RC = Reduced Cues, BN = Background Noise, DS = Distortion, AV = Aversiveness.

amounts of unaided problems under this latter condition (mean unaided problems = 28.95, $t_{Ho=0}$ = 21.02, p < .00001). Finally, comparing the amount of benefit for the different subscales, significantly greater benefit was reported for RV, RC, and BN than for EC or FT. One scenario that could lead to this result would be that subjects reported no unaided problems under EC and FT environments, a real possibility for individuals with normal hearing through 2 kHz. In that case, there would be no room for any benefit, since benefit is defined simply as the percent of unaided problems minus the percent of aided problems. For our subjects, however, significant amounts of unaided problems under EC and FT environments were reported (40% and 29%, respectively). Naturally, the amount of problems reported in the remaining speech categories (RV, RC, and BN) were higher still (53%, 55%, and 54%, respectively), perhaps leaving greater opportunities for benefit to be observed. The amount of benefit reported in these more difficult listening environments (26%, 25%, and 25%, respectively) could have been reported in the easier listening environments (EC and FT) and were not precluded because of lower unaided scores.

Predicting user benefit received from hearing aids represents one of the greatest challenges in clinical audiology. Apparently, exact matches to prescribed frequency-gain targets are not necessary for deriving benefit from hearing aids, assuming that the deviations are within some reasonable criterion (e.g., ± 10–15 dB). Presumably, larger deviations from prescriptive targets would begin to affect benefit scores, but at this point we cannot say how large a deviation can be tolerated for this population.

Are there other factors that are more informative regarding perceived hearing aid benefit? To address this question, we looked at a number of different audiologic and demographic factors that might have influenced the obtained benefit scores. The factors examined included age, employment status (full time, retired, and part time), pure-tone average at 2, 3, and 4 kHz (averaged across ears), slope of the hearing loss from 2 to 4 kHz (averaged across ears), the average rms deviation from NAL targets (averaged across frequency and ears), months of hearing aid use, hours of hearing aid use per day, and type of aural rehabilitation program attended. To study the possible influence of each of these factors on hearing aid benefit, a separate stepwise multiple regression analysis was conducted for each of the six PHAB subscales that resulted in significant benefit. The results are shown in Table 1.

The factor most likely to affect perceived hearing aid benefit was the number of hours per day that the hearing aid was worn (identified for five of six subscales). The longer subjects wore their aids, the greater the benefit reported. The second most important factors were the subject's age and duration of hearing aid use in months (each identified for three of six subscales). Not surprisingly, the subject's age was negatively correlated with hearing aid benefit, with younger subjects reporting greater hearing aid benefit. Audiometric and hearing aid factors (average hearing loss and deviation from NAL targets) were of little value in predicting hearing aid benefit, appearing in the final subset model of only one PHAB subscale (BN). Hearing loss slope and subjects' participation in short or long AR programs did not correlate significantly with PHAB benefit. Overall, our efforts to predict hearing aid benefit were rather unsatisfactory. Only between 6 and 17 percent of the variance across subjects in benefit scores could be accounted for by the various combinations of factors.

DISCUSSION

It was initially hypothesized that subjects in group 2, who had significant deviations from NAL prescriptive recommendations, would report lower benefit scores than subjects with more closely matched NAL targets. This hypothesis was based on the assumption that the NAL prescriptive formula offers the preferred gain and frequency response for patients with hearing loss above 2000 Hz. The closer match to the NAL prescriptive target achieved in group 1 subjects, however, did not ensure more user benefit as indicated by PHAB scores. There are a number of possibilities for this finding. First, although the NAL-R prescriptive formula is the mostly widely used when fitting linear hearing aids, the type of prescriptive formula that is most appropriate for the patients with high-frequency hearing loss is not clear (Byrne and Cotton, 1988). Second, the difference between target and actual gain values, although statistically significant, was generally small and may have been clinically irrelevant. Mismatches to prescribed target gains may only become important when there are large deviations (e.g., greater than 15 dB). Third, exact match to NAL, or any other prescriptive target, may not be required when fitting this population. Target gain values are more appropriately

Table 1 Stepwise Multiple Linear Regression Analyses for the Six Profile of Hearing Aid Benefit Subscales that Resulted in Significant Benefit Scores

PHAB Subscale	*Final Subset Factors*	*Coefficient*	*t Value*	*p Value*
Ease of Communication	F (3,130) = 8.118, p = .00005, r^2 = .158			
	Hours	4.457	3.720	.0003
	Employment	–3.382	–2.533	.0125
	Duration	0.534	2.972	.0035
	Constant	6.175		
Familiar Talker	F (1,132) = 8.438, p = .00431, r^2 = .060			
	Hours	3.143	2.905	.0043
	Constant	7.640		
Reverberation	F (2,131) = 8.284, p = .00041, r^2 = .112			
	Age	–0.204	–1.747	.0830
	Hours	4.962	3.577	.0005
	Constant	23.892		
Reduced Cues	F (2,131) = 9.611, p = .00013, r^2 = .128			
	Age	–0.402	–3.758	.0003
	Hours	2.610	2.054	.0420
	Constant	40.882		
Background Noise	F (5,103) = 4.185, p = .00167, r^2 = .169			
	Age	–0.318	–2.138	.0349
	Hearing loss	0.450	1.535	.1277
	National Acoustic Laboratories (NAL)	–1.198	–1.519	.1318
	Hours	5.400	3.281	.0014
	Duration	0.440	1.778	.0783
	Constant	6.846		
Aversiveness	F (1,132) = 10.821, p = .00129, r^2 = .076			
	Duration	0.646	3.289	.0013
	Constant	–36.232		

Initial predictive factors included age, employment status, average hearing loss (2, 3, 4 kHz), hearing loss slope (2–4 kHz), average rms deviation from NAL targets (0.5–4.0 kHz), duration of hearing aid use (in months), hours per day of hearing aid use, and type of aural rehabilitation program.

considered as starting points in the fitting process and not the end goal. Fourth, it is possible that, for some of the subjects in this study, the gain prescribed at high frequencies is of limited value, making deviations in the amount of achieved gain irrelevant. Hogan and Turner (1998) suggest that for subjects whose high-frequency thresholds are greater than 55 dB, there is negligible contribution to speech recognition from amplification for frequencies above 3000 Hz. Consequently, deviations in achieved gain at frequencies 3 kHz and above would be expected to have no effect on perceived benefit from amplification.

To look at this more closely, we grouped our subjects according to whether the average hearing threshold (across ears) at 3 and 4 kHz was 60 dB or greater. Thirty-five of the 134 subjects had average high-frequency losses that met this criterion. A repeated-measures ANOVA with the PHAB scales as within-subject factors and the high-frequency hearing loss status as a between-subject factor revealed no significant main effect for hearing loss [F (1, 132) = 0.630, p = .429]. However, there was a significant interaction between PHAB subscales and high-frequency hearing loss status [F (6, 792) = 2.754, p = .012]. Post hoc examination of this interaction revealed that for each of the five subscales pertaining to speech intelligibility (EC, FT, RC, RV, and BN), the subjects who had the greater high-frequency hearing loss reported slightly more hearing aid benefit. For the subscale BN, this difference reached significance (t = –2.03, p = .045). These results are in the opposite direction suggested by Hogan and Turner and, at the very least, show that patients with severe high-frequency hearing loss (and near normal hearing at lower frequencies) can achieve benefit from high-frequency amplification.

Among the various demographic and audiometric factors examined that might relate to hearing aid benefit, hours of use emerged as a dominant factor. This result was not surprising as the positive relationship between benefit and hours of hearing aid use has been observed frequently (Brooks, 1979; Haggard et al, 1981; Hutton, 1983; Oja and Schow, 1984; Schum, 1992). In addition, subjects with greater high-frequency hearing loss wore their aids more frequently than subjects with less high-frequency loss. The positive relationship between degree of hearing loss and hours of use has been suggested by previous authors (Ewersten, 1974; Kaptyen, 1977a, b; Surr et al, 1978).

A disappointing finding was the fact that type of AR program attended (2 hours vs 3½ days) seemed to have no predictive relationship with perceived hearing aid benefit, especially because the relationship between the type of AR program and hearing aid benefit had been observed previously (Surr et al, 1978; Abrams et al, 1992). The long AR program provides an opportunity to experience immediate, extensive use of their hearing aids. Subjects attending the long AR program receive frequent reminders concerning the use of the hearing aids and are taught to have more realistic expectations regarding the listening situations in which their hearing aids should be of benefit (e.g., EC, FT, RC) and those where the hearing aids might be less useful (e.g., RV and BN). Taken as a whole, the training and experience of the long AR program should have translated into subjects' wearing their hearing aids for longer periods during the day and greater reported benefit. In fact, this is what did essentially happen. Figure 4 shows small but consistent mean differences in hours used, and the amount of benefit reported, for attendees of the two AR programs. Although differences were not statistically significant, subjects who attended the long AR program tended to wear their aids more hours each day than attendees of the short AR program (see Fig. 4, top). Further, attendees of the long AR program reported slightly more benefit in all five of the speech subscales (see Fig. 4, bottom).

In the present study, age was another factor that was associated with the amount of reported hearing aid benefit, especially for the more difficult listening situations (RC, BN, and AV). In general, older subjects tended to report less benefit than younger subjects for each of the five speech subscales and greater tolerance of their aids under aversive listening situations (AV). Significant age effects were observed for the subscales RC, BN, and AV. Why this is so is somewhat unclear. There was no difference in hearing thresholds or slope of hearing loss between younger and older subjects. There was also no difference in the number of hours of use between younger and older subjects. One difference between younger and older subjects was their employment status, with more older subjects working in part-time jobs or retired from the workforce than younger subjects. It is possible that reduced exposure to work environments, where communication is critical and background noise may be a common problem, led subjects to view their hearing aids as less important and therefore less beneficial. However, a recent paper by Schum (1999) suggests that

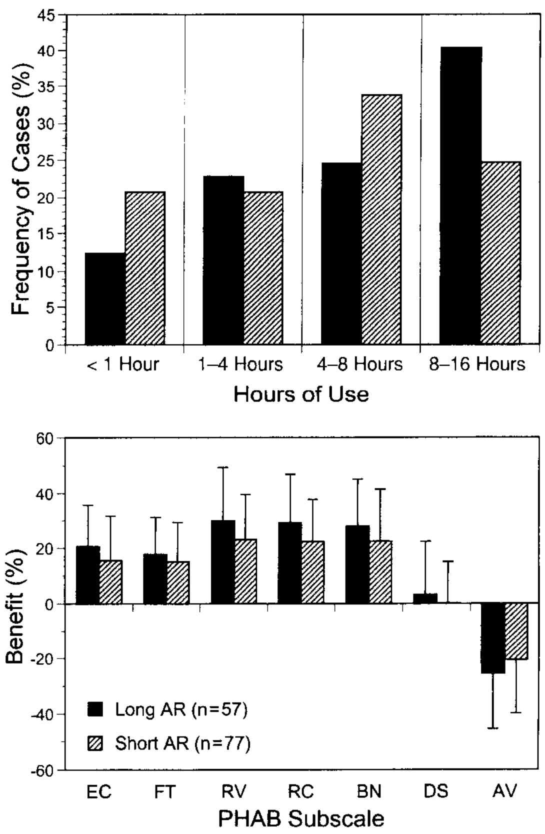

Figure 4 (Top) Number of subjects (in percent) reporting specified hours of hearing aid use per day as a function of the type of aural rehabilition program attended. (Bottom) Profile of Hearing Aid Benefit (PHAB) scores as a function of type of aural rehabilitation program attended. Error bars are 1 SD. EC = Ease of Communication, FT = Familiar Talker, RV = Reverberation, RC = Reduced Cues, BN = Background Noise, DS = Distortion, AV = Aversiveness.

hearing aid benefit cannot be reliably predicted based on perceived needs or expectations.

CONCLUSION

Individuals with normal hearing through 2000 Hz and moderate to severe hearing loss in the higher frequencies are often considered marginal candidates for hearing aids because their communication needs are mostly satisfied without the use of prosthetics. However, in part because of their entitlements as active duty or retired military, patients evaluated at the AASC with this configuration of hearing loss are routinely fit binaurally with hearing aids. Based on subjective reports using the PHAB, this cohort of patients received significant amounts of benefit for speech communication from amplification. The amount of reported benefit did not appear to be influenced by deviations from NAL-R prescriptive targets caused by limitations in gain and frequency response characteristics of different hearing aids. The primary factor related to benefit on the PHAB was the number of hours of hearing aid use per day. This poses the obvious question of whether wearing hearing aids for longer periods each day facilitates the derivation of hearing aid benefit or whether beneficial hearing aids are simply worn more frequently. If the former is true, then appropriately structured AR programs can have a positive impact on perceived hearing aid benefit by encouraging patients to wear their aids even in situations where the benefits of amplification are not immediately apparent. Of course, even if the hearing aid provides great benefit to speech understanding, patients cannot realize these benefits unless they wear their aids. Here again, AR programs can have a positive effect by helping to reduce obstacles (e.g., cosmetic considerations) that might prevent patients from using their aids. However, if hearing aid benefit is primarily determined by factors other than those identified in this study, as we suspect based on the low overall predictabilty of benefit scores, then these (as yet unidentified) factors will need to be identified and characterized systematically.

Acknowledgment. This research was supported by grant number DC 00792 from the National Institute of Deafness and Other Communication Disorders to Walter Reed Army Medical Center and by the Clinical Investigation Service, Walter Reed Army Medical Center, under Work Unit #2525. Portions of this work were presented at the Annual Convention of the American Speech-Language-Hearing Association, November 1993, Anaheim, CA. The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. The authors would like to thank Brian C.J. Moore and an anonymous reviewer for their comments on an earlier draft of this manuscript.

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