Technology, Expectations, and Adjustment to Hearing Loss: Predictors of Hearing Aid Outcome

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Abstract

This study examined the influence of technology, demographic factors, and prefitting expectations, attitudes, and adjustment to hearing loss on hearing aid outcome. Clients obtaining new hearing aids completed questionnaires measuring personal adjustment to hearing loss, expectations of and attitudes toward hearing aids, and hearing aid benefit. Eighty-one percent of the 200 subjects completing the prefitting questionnaires returned questionnaires evaluating hearing aid outcome. Factors affecting hearing aid use, overall satisfaction, and benefit were investigated using regression analyses. Higher use time was associated with higher prefitting expectations and greater acceptance of hearing loss. Greater benefit in easy and difficult listening situations was predicted by higher prefitting expectations. Multiple-memory hearing aids produced higher satisfaction. Benefit was greater for multiple-memory, multiple-channel, and wide dynamic range compression aids. Findings were consistent with previous studies showing positive outcomes for newer technologies but also showed that two subjective factors, prefitting hearing aid expectations and acceptance of hearing loss, significantly influenced hearing aid outcome.

Key Words: Attitude, benefit, expectations, hearing aid, hearing aid use, personal adjustment, questionnaire, satisfaction, technology

Abbreviations: APHAB = Abbreviated Profile of Hearing Aid Benefit, BTE = behind the ear, CIC = completely in the canal, CPHI = Communication Profile for the Hearing Impaired, HAPI = Hearing Aid Performance Inventory, HARQ = Hearing Attitudes in Rehabilitation Questionnaire, HHIE = Hearing Handicap Inventory for the Elderly, HPI = Hearing Performance Inventory, ITC = in the canal, ITE = in the ear, MAPHAB = Modified Abbreviated Profile of Hearing Aid Benefit, MELU = multiple environmental listening utility, MPAS = Modified Personal Adjustment Scale, PHAB = Profile of Hearing Aid Benefit, SADL = Satisfaction with Amplification in Daily Living, WDRC = wide dynamic range compression

A variety of measures have been developed to assess hearing aid outcome including aided performance and benefit, satisfaction with hearing aids, and amount of hearing aid use (Brooks, 1990; Dillon et al, 1999; Humes, 1999). Hearing aid benefit can be defined as an increase in hearing ability after provision of an aid. Objective benefit measures do not require the wearer to express an opinion or judgment regarding the hearing aids. There are many objective speech recognition tests that can be used to assess benefit (Levitt and Resnick, 1978) and purely acoustic tests of hearing aid function in a coupler or on the person's ear (Wetzel and Harford, 1983; Mueller, 1992). Subjective measures of benefit require a judgment or opinion, such as loudness or quality judgments using rating scales (e.g., Arlinger and Billermark, 1999; Jenstad et al, 1999).

Subjective hearing aid benefit also has been measured as reduction in perceived disability or handicap (Weinstein, 1990). The International Classification of Impairments, Disabilities, and Handicaps developed in 1980 by the World Health Organization defines disability as the degree to which a physical impairment causes
dysfunction and handicap as the psychosocial sequela of this (Badley and Lee, 1987a, b; Badley et al, 1987; Arnold and MacKenzie, 1998).

Many different self-assessment scales have been developed to measure hearing disability and handicap (Noble, 1998), including the Profile of Hearing Aid Benefit (PHAB, Cox et al, 1991) and the Hearing Handicap Inventory for the Elderly (HHIE, Ventry and Weinstein, 1982), which have been used extensively to measure hearing aid benefit in the realms of disability (PHAB) and handicap (HHIE).

Humes (1999) identified several components of hearing aid outcome including aided performance measured by speech recognition scores and the HHIE, hearing aid use time, loudness and sound quality ratings, and satisfaction. Satisfaction is an internalized construct that can be measured as a single global measure (Brooks, 1985; Kuk and Pape, 1993) or as separate components (Kochkin, 1993, 1995; Cox and Alexander, 1999). Although overall satisfaction is related to benefit, satisfaction and benefit are separate dimensions of hearing aid success (Kochkin, 1995; Purdy and Jerram, 1998; Humes, 1999).

The psychosocial effects of hearing aids have also been studied. Mulrow et al (1990) reported improved cognitive function and reduced depression in clients fitted with hearing aids compared with a control group of waiting list clients. Bridges and Bentler (1998) found higher ratings of life satisfaction in successful hearing aid wearers. Garstecki and Erler (1998) found fewer depressive tendencies among hearing aid wearers than hearing aid nonwearers, and Crandell (1998) found that hearing aids have a positive impact on functional health status in elderly listeners. In a recent large study of hearing-impaired listeners and their family and friends, Kochkin and Regin (2000) reported many positive effects of hearing aids on quality of life.

## Predicting Hearing Aid Outcome

Many variables have been investigated as possible predictors of success with hearing aids. For example, Mulrow et al (1992) found that greater baseline perceived handicap, younger age, lower education level, greater degree of high-frequency hearing aid gain, better near visual acuity, and fewer number of medications all positively influenced hearing aid outcome. The present study investigated the effects on hearing aid outcome of demographic, hearing aid technology, and subjective predictor variables.

A number of previous studies have examined these variables.

### Age, Hearing Loss, and Gender

Deterioration in central auditory function in older hearing aid wearers can adversely affect hearing aid outcome (Kricos et al, 1987; Gatehouse, 1990; Stach et al, 1991). General ill health, loss of mobility, and social isolation (Welzl-Müller and Stephan, 1986; Stephens and Meredith, 1991; Evenhuis, 1995; Cohn, 1999) also reduce success with hearing aids in elderly hearing aid wearers. This is consistent with reports of reduced hearing aid performance with increasing age (Crowley and Nabelek, 1996; Jerram and Purdy, 1997).

People with greater hearing loss wear their hearing aids more often (Brooks, 1985; Satherley, 1992). The reported relationship between audiometric thresholds and hearing aid benefit is variable, ranging from nonsignificant (Schum, 1992) to significant (Kochkin, 1995), with greater benefit usually being associated with greater loss. As expected, poorer hearing aid performance is associated with worse hearing thresholds (Purdy and Jerram, 1998).

Garstecki and Erler (1998) found differences between the sexes when they compared hearing aid wearers and nonwearers using the Communication Profile for the Hearing Impaired (CPHI) inventory. Significant gender differences were present for 6 of the 25 CPHI scales (Problem Awareness, Social Communication Importance, Nonverbal strategies, Anger, Stress, and Denial). Women were more likely to admit to communication problems, use nonverbal strategies to remedy difficult communication situations, and report feelings of anger, stress, and negative emotions than men. Crowley and Nabelek (1996) found no effect of gender on ratings of hearing aid performance, but Garstecki and Erler's (1998) results suggest that gender may affect some hearing aid outcome measures.

### Hearing Aid Technology

Choice of monaural or binaural hearing aid fitting affects outcome, with greater success found for binaural fittings (Brooks, 1984; Day et al, 1988; McKenzie and Rice, 1990), particularly for directional hearing aids (Leeuw and Dreschler, 1991).

A variety of new hearing aid technologies are currently available that aim to enhance perception of speech, particularly in background
noise. This includes digital circuitry, multiple memories, multiple microphones, multiple-frequency channels, and various forms of compression. Kochkin (1996) found that outcomes were consistently better for newer "high-performance" hearing aids (higher overall satisfaction, perceived improvement in quality of life and benefit, etc.). Modern digital hearing aids generally provide clearer sound than older analog aids (Kates and Weiss, 1996; Kiessling, 1996; Arlinger et al, 1998; Valente et al, 1998). Multiple-memory hearing aids have proved an effective way of adjusting amplification for specific listening situations (Keidser, 1995; Berninger and Nordstrom, 1997). Dual-microphone systems result in improved speech perception in noise (Valente, 1999). Overall satisfaction with hearing aids is highly related to the number of listening situations in which wearers' needs are met (Kochkin, 1996). Kochkin (1996) found that multiple-memory and multiple-microphone hearing aids, allowing different amplification characteristics in different listening situations, provide the highest satisfaction.

Channelling of the incoming signal into more than one frequency band allows independent adjustment according to the degree of hearing loss in that frequency region. Many modern hearing aids have multiple channels, allowing compression parameters to vary across frequency. Kochkin (1996) found higher "usage satisfaction" among users of multiple-channel hearing aids compared with single-channel aids.

It is still not clear whether new nonlinear compression circuits, in which amplification is reduced for loud sounds, are better than linear (equal amplification for loud and soft sounds) for speech understanding in noise (Byrne, 1996; Verschuure et al, 1996). Dillon (1996) reviewed the compression literature and concluded that for speech in quiet at a comfortable level, no compression scheme yet tested offers better intelligibility than individually selected linear amplification.

Variable results have been found regarding the relative advantages of the four main hearing aid styles: behind the ear (BTE), in the ear (ITE), in the canal (ITC), and, recently, completely in the canal (CIC). Smaller ITE and CIC hearing aids are less associated with the stigma of hearing loss than the more conspicuous BTE style (Brooks, 1994). ITE hearing aids can present handling problems in older hearing aid users (Meredith and Stephens, 1993) but not consistently (Upfold and May, 1990). The latter study found no difference in performance between ITC, ITE, and BTE hearing aids in elderly hearing aid wearers. CIC hearing aids appeal to younger, less impaired individuals, but wearers rate CIC hearing aids lower on reliability, ease of adjusting, and performance relative to cost (Kochkin, 1995).

**Psychosocial Factors**

Several studies have examined the effects of personality on hearing aid outcome (Gatehouse, 1994; Scott et al, 1994; Cox et al, 1999). Cox et al (1999) found that a more outward-looking personality gained higher benefit in the Easy Listening, Reverberant, and Background Noise subscales of the abbreviated version of the PHAB (APHAB). Gatehouse (1994) found that depression was associated with less hearing aid use and lower reports of hearing aid benefit and satisfaction. Other aspects of personality measured with the Crown-Crisp Experiential Index were also highly correlated with hearing aid outcome (Gatehouse, 1994; Noble, 1998).

Several studies have examined the influence of attitudes toward hearing loss and hearing aids on hearing aid outcomes (Hickson et al, 1986, 1999; Brooks, 1989; Gatehouse, 1994; Hallam and Brooks, 1996). Using the Hearing Attitudes in Rehabilitation Questionnaire (HARQ), Hallam and Brooks (1998) found that clients who were least distressed by their hearing difficulties and reported not wanting or needing a hearing aid used their aids least frequently and evaluated them less highly in listening situations. Gatehouse (1994) and Hickson et al (1986, 1999) found a significant positive relationship between attitudes toward hearing aids and their use.

Personal adjustment to disability also has been associated with rehabilitation outcome (Brown and Munford, 1984; Corso, 1987; Burke et al, 1988) and is seen as important in offering guidelines for aural rehabilitation (May, 1986; Stephens, 1996). Crowley and Nabelek (1996) found that personal adjustment to hearing loss measured using the CPHI was predictive of hearing aid performance in difficult listening situations measured using the Profile of Hearing Aid Performance (Cox and Gilmore, 1990). In contrast, Cox and Rivera (1992) found that CPHI composite scores were not predictive of PHAB benefit.

Counselling to ensure that hearing aid wearers make informed choices, have realistic expectations, and know how to use hearing aids has been found to influence hearing aid success in adults (Brooks and Johnson, 1981; McCarthy et
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al. 1990; Rose and Pool, 1994; Kapteyn et al, 1997; Kochkin, 1999). Kricos et al (1991) developed a 48-item expectations checklist and found that 87 percent of participants had high expectations of hearing aids. Schum (1999) found that candidates for amplification tend to expect more benefit than they will typically achieve, especially when listening to speech in noise or without visual cues. In contrast, Bentler et al’s (1993) results suggested that performance exceeded expectations. Schum (1999) concluded that hearing aid benefit could not be reliably predicted from perceived need or expectation. Brooks and Johnson (1981) reported that prefitting counselling had a positive effect on hours of hearing aid use and satisfaction with hearing aids, which suggests that realistic expectations should improve hearing aid outcomes.

The present study was designed to evaluate which, if any, of a number of the predictor variables discussed above influence three measures of hearing aid outcome, perceived hearing aid benefit, overall satisfaction, and daily hours of hearing aid use.

METHOD

Subjects

A total of 12 private and 7 public hospital audiology clinics participated in the study. Over an approximately 18-month period, adult prospective hearing aid wearers undergoing their initial hearing aid evaluation were introduced to the study by their audiologist. Consent forms were received from 225 potential participants. Each was sent questionnaires examining personal adjustment to hearing loss, hearing aid expectations, attitudes to hearing aids (Appendix), and unaided hearing ability, to be completed and mailed to the researcher prior to fitting of hearing aids. Complete sets of questionnaires were received from 200 individuals (89% response rate). These 200 individuals received a copy of the aided version of the APHAB questionnaire (Cox and Alexander, 1995), which evaluates unaided and aided hearing performance in 24 listening situations. Hearing aid benefit is measured as the difference in hearing performance with and without a hearing aid. A positive difference in scores between unaided and aided versions indicates that hearing aids are beneficial. The APHAB measures benefit in four types of listening environment: Ease of Communication, Reverberation, Background Noise, and Aversiveness of Sounds. Factor analysis of the aided version of the APHAB for New Zealand listeners shows

from 31 to 88 years (mean = 70.5 years, SD = 10.8). Twenty-five were fully employed, 13 were partially employed, and 124 were not employed outside the home. Sixty-one subjects were new hearing aid users, and 101 (62%) had some prior hearing aid experience. Figure 1 shows the subjects’ mean right and left ear pure-tone thresholds in the frequency range of 0.5 to 4 kHz. All had sensorineural hearing loss.

Outcome Measures

Hearing aid outcome was measured in three ways: daily hearing aid use time, hearing aid benefit, and overall satisfaction. Overall hearing aid satisfaction was measured using a single 20-point rating scale ranging from “very, very dissatisfied” (1) to “very, very satisfied” (20). Subjects were asked to indicate the amount of hearing aid use (0–1, 1–4, 4+ hours per day). Hearing aid benefit was measured using a modified version of the APHAB questionnaire (Cox and Alexander, 1995), which evaluates unaided and aided hearing performance in 24 listening situations. Hearing aid benefit is measured as the difference in hearing performance with and without a hearing aid. A positive difference in scores between unaided and aided versions indicates that hearing aids are beneficial. The APHAB measures benefit in four types of listening environment: Ease of Communication, Reverberation, Background Noise, and Aversiveness of Sounds. Factor analysis of the aided version of the APHAB for New Zealand listen-

Figure 1 Mean left and right ear audiometric thresholds (dB HL) of the 162 subjects completing the study. Error bars show standard deviations.
ers (Purdy and Jerram, 1998) revealed three factors that roughly matched the four scales of Cox and Alexander (1995). These factors represent easy and difficult listening situations and listening to aversive environmental sounds. Purdy and Jerram (1998) dropped two items from the questionnaire due to poor response rates. The resulting 22-item questionnaire, the MAPHAB, was used in the present study as a measure of hearing aid outcome. The APHAB response scale was altered from the original to be an equal-interval scale (Keller et al., 1998), with a scale ranging from never (0%) to always (100%) with 10 percent increments marked on the scale.

**Client and Hearing Aid Predictor Variables**

For subjects who completed the study, clinicians provided information on subject age; pure-tone hearing thresholds at 0.5, 1, 2, and 4 kHz; type of hearing loss; monaural or binaural fitting, hearing aid style; and type of hearing aid technology (peak clipping, output, input, and wide dynamic range compression [WDRC]; multiple microphone; multiple memory; multiple channel). When they completed the final hearing aid questionnaires, subjects were asked to indicate the duration of hearing aid experience (<6 weeks, 6 weeks–11 months, >1 year) and employment status (full time, part time, not employed outside the home).

The adjustment factor of the CPHI, consisting of 100 items comprising 13 of the 25 original CPHI subscales (Demorest and Erdman, 1986, 1987, 1989), has been used to measure personal adjustment to hearing loss in a range of domains (Crowley and Nabelek, 1996; Erdman and Demorest, 1998; Jerram and Purdy, 1999). Jerram and Purdy (1999) obtained high (> 0.8) alpha internal consistency values (Cronbach, 1951) for New Zealand listeners with hearing impairment for 7 of the 13 adjustment factor subscales. Three of the adjustment subscales with high internal consistency (Jerram and Purdy, 1999), Acceptance of Loss, Stress, and Denial, were used to assess personal adjustment to hearing loss in the present study. The 25-item questionnaire containing the three adjustment subscales was called the Modified Personal Adjustment Scale (MPAS).

Items in the Acceptance of Loss and Stress subscales are negatively worded, with a 5-point rating scale ranging from "strongly disagree" (1) to "strongly agree" (5). A high score indicates poor personal adjustment in coping with the statement described. According to the analysis procedure of Demorest and Erdman (1987), scores are reversed, and after reversal, a high score is indicative of a good level of personal adjustment. For items in the Denial subscale, a low score indicates denial of a negatively worded statement. Persistent disagreement with common emotional reactions experienced by listeners with hearing impairment represents an unwillingness to admit that a problem exists—thus, a poor personal adjustment to the problem. Items in the Denial subscale are therefore not reversed to keep scoring for this subscale parallel to that of the other subscales.

Prefitting attitudes toward hearing aids were measured using the factor 1 ("hearing aid stigma") items in the hearing aid section of the HARQ (Hallam and Brooks, 1996). The HARQ subscale consists of eight negatively worded items (e.g., "It would make me feel old to wear a hearing aid") and one positively worded item (item 9, "I think the BTE hearing aids are really quite small and inconspicuous"). Scoring ranges from "true" (1) to "not true" (3). Scoring is reversed for item 9; thus, a high score represents a positive attitude toward hearing aids.

Prefitting hearing aid expectations were measured using the expectations questionnaire developed by Seyfried (1990). Seyfried's questionnaire contains 12 items, 7 of which are positively worded (e.g., "My hearing aids will fit comfortably") and 5 of which are negatively worded (e.g., "I will adjust slowly to my hearing aids"). Scoring ranges from "strongly agree" (1) to "strongly disagree" (6) for all items. For analysis, scoring is reversed for the negatively worded items so that a low score represents high expectations.

**RESULTS**

**Hearing Aid Characteristics**

Ninety-five subjects (59%) were binaurally fitted, and 67 (41%) were monaurally fitted. Figure 2 shows numbers of subjects wearing hearing aids with each of the hearing aid technologies that were examined as predictors of outcome. The most widely prescribed technology was WDRC. Very few subjects wore linear peak-clipping hearing aids. Multiple-memory and multiple-frequency channel aids were prescribed more often than multiple-microphone aids.
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WDRC
Other C
P-clip
M-band
M-mem
M-mic

Figure 2 Numbers of subjects using each type of hearing aid technology: wide dynamic range compression (WDRC), other types of input or output compression (Other C), peak clipping (P-Clip), multiple channels (M-band), multiple memories (M-mem), and multiple microphones (M-mic). These results are based on the audiologists' reports for the 162 subjects who returned the aided questionnaires.

Item Analysis of Prefitting Questionnaires

Item analyses were performed to determine internal reliability of the personal adjustment, expectations, and hearing aid attitudes questionnaires completed by the 200 subjects who responded to the first mail-out. Only questionnaires with no missing values were included in the analysis. Reliability was excellent (Cronbach's alpha = 0.90-0.92) for the MPAS personal adjustment subscales, Acceptance of Loss (n = 153), Stress (n = 152), and Denial (n = 144). Item 9 of the HARQ attitudes scale was poorly correlated with the other items in the questionnaire. Cronbach's alpha for the HARQ, excluding item 9, was 0.81 (n = 189). Three items in the expectations questionnaire had very poor item-total correlations (9, 11, and 12) and were not included in subsequent analyses. With these three items excluded, Cronbach's alpha was 0.60 for the expectations questionnaire (n = 171). Bentler et al (1993) analyzed subsets of Seyfried's (1990) expectations questions and derived a subset of five items yielding a higher alpha value (0.74). This subset resulted in a poor alpha value (0.45) in the present study, lower than that obtained when all 12 items were included (0.49).

Results for Subjects Completing Aided Questionnaires

Table 1 shows means and standard deviations for the MPAS subscales and the HARQ and expectations prefitting questionnaires for the 162 subjects completing the study, after omission of item 9 from the HARQ and items 9, 11, and 12 from the expectations questionnaire. Only 135 subjects (83%) completed all items for the expectations questionnaire, so an expectations score was calculated for the 97 percent of subjects who completed at least 7 of the 9 questions. For the MPAS subscales and the HARQ questionnaire, most subjects (89-94%) responded to every item; thus, analyses were based on subjects who responded to all items.

For analysis of the expectations questionnaire, scoring is reversed for the negatively worded items so that a low score represents high expectations. The mean expectations score of 2.3 of a maximum of 6 indicates that, on average, subjects had positive expectations of hearing aids. For the HARQ questionnaire, a high score represents a positive attitude toward hearing aid use. HARQ scores indicated a range of attitudes to hearing aids from negative to positive, with the mean score in the middle of the 3-point scale. A high MPAS score indicates a

Table 1: Means, SDs, Range, and Number of Subjects for the MPAS Personal Adjustment Subscales (Acceptance of Loss, Stress, Denial) and the HARQ Attitudes* and Expectations† Questionnaires.

<table>
<thead>
<tr>
<th></th>
<th>Acceptance (/5)</th>
<th>Stress (/5)</th>
<th>Denial (/5)</th>
<th>Attitude (/3)</th>
<th>Expectations (/6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.65</td>
<td>3.19</td>
<td>2.61</td>
<td>1.36</td>
<td>2.30</td>
</tr>
<tr>
<td>SD</td>
<td>1.31</td>
<td>1.23</td>
<td>1.23</td>
<td>0.32</td>
<td>0.56</td>
</tr>
<tr>
<td>Range</td>
<td>1.22-4.20</td>
<td>1.00-5.00</td>
<td>1.00-5.00</td>
<td>1.00-2.75</td>
<td>1.49-4.16</td>
</tr>
<tr>
<td>N</td>
<td>155</td>
<td>155</td>
<td>143</td>
<td>157</td>
<td>157</td>
</tr>
</tbody>
</table>

*Excluding item 9; †excluding items 9, 11, and 12

Data are shown for subjects completing all MPAS and HARQ items and at least seven expectations items. High values indicate good personal adjustment (Acceptance, Stress, Denial), a positive attitude (HARQ) toward hearing aids, and low expectations. The maximum rating is shown in parentheses for each scale.
high level of personal adjustment. The MPAS mean data showed a moderately high acceptance of hearing loss and adjustment to stress related to hearing loss and a moderate level of awareness of communication problems.

Only two subjects wore their aids 1 hour or less per day, 48 (26%) wore their aids 1 to 4 hours, and 112 (69%) wore their aids 4+ hours per day. For the 162 subjects completing the study, ratings of overall hearing aid satisfaction ranged from 2 to 20. Only 5 subjects had satisfaction scores below 10. Mean satisfaction was 15.33 (SD = 3.33) or 77 percent of the entire scale. Thus, on average, people were very satisfied with their hearing aids.

Only 58 percent of subjects completed all of the unaided and aided MAPHAB items. Ninety percent of subjects (n = 146) completed at least 80 percent of the MAPHAB items (i.e., ≥17 of 22). For these subjects, item 16 ("The sounds of construction work are uncomfortably loud") had the poorest response rate (78%) of the individual items. Response rates for the other individual MAPHAB items ranged from 92 to 100 percent. Means and standard deviations for MAPHAB benefit scores are shown in Table 2 for subjects who responded to at least 80 percent of the MAPHAB items. On average, benefit scores were slightly higher for the difficult listening than for the easy listening factor and were lowest for the aversiveness of sounds factor.

**Relationships between Outcome Measures**

The relationship between the satisfaction and benefit outcome measures was investigated by calculating Pearson correlation coefficients for the 146 subjects completing at least 80 percent of the MAPHAB items. Satisfaction was correlated with factors 1 (r = .224, p = .007) and 2 (r = .312, p < .001) but not factor 3 (r = .072, p = .387) benefit scores. The strongest relationship between satisfaction and benefit scores was for difficult listening situations (factor 2). Figure 3 shows satisfaction ratings and MAPHAB benefit as a function of hearing aid use time. On average, subjects who wore their aids more had higher satisfaction ratings and higher factors 1 and 2 MAPHAB benefit scores.

**Effects of Predictor Variables on Outcome Measures**

Ordinal logistic regression analyses were used to investigate whether demographic, hearing aid technology, or subjective factors had an effect on hours of hearing aid use, satisfaction, and benefit. Factors that were investigated included age, gender, employment status, type of clinic (public vs private), prior hearing aid experience, four-frequency pure-tone average (combined and separate ears), monaural versus binaural fitting, hearing aid style (BTE, ITE, ITC, CIC), hearing aid input-output characteristic (WDRC, input compression, output limiting compression, peak clipping), "high-performance" hearing aid features (multiple channel, multiple memory, multiple microphone),

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Means, SDs, and Range for the Satisfaction Ratings (Using a 20-Point Scale) and MAPHAB Factors 1 (Easy Listening), 2 (Difficult Listening), and 3 (Aversive Sounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction</td>
<td>Factor 1</td>
</tr>
<tr>
<td>Mean</td>
<td>15.33</td>
</tr>
<tr>
<td>SD</td>
<td>3.33</td>
</tr>
<tr>
<td>Range</td>
<td>2–20</td>
</tr>
</tbody>
</table>

Percent hearing benefit is shown for MAPHAB factors 1 to 3. Data are shown for the subjects who completed at least 80% of the MAPHAB unaided and aided items (n = 146).
personal adjustment to hearing loss (MPAS Acceptance of Loss, Stress, and Denial subscales), attitudes to hearing aids (HARQ), and expectations of hearing aids. Only subjects with complete information were included in each regression analysis.

The regression analysis of the hours of use data was based on 113 subjects. Prefitting expectations ($\chi^2 = 12.36, df = 1, p = .0004$) and Acceptance of Loss ($\chi^2 = 3.9, df = 1, p = .048$) were the two factors that significantly affected hours of hearing aid use. Subjects with higher prefitting expectations (i.e., lower scores) and better acceptance of loss (i.e., higher scores) wore their hearing aids more (Fig. 4).

One hundred and fourteen subjects had complete information and were included in the regression analysis of the satisfaction data. Only the use of multiple-memory hearing aids had an effect on overall hearing aid satisfaction ($F[1,89] = 5.57, p = .02$). Users of multiple-memory hearing aids had higher satisfaction scores than those without. Table 3 shows that satisfaction ratings were highest for users of multiple microphones, but only a small group of subjects was fit with this technology.

Prefitting expectations ($F[1,88] = 8.28, p = .005$), employment status ($F[2,88] = 5.28, p = .007$), and the use of multiple-memory ($F[1,88] = 7.01, p = .01$) or multiple-channel ($F[1,88] = 5.18, p = .03$) hearing aids all had an effect on MAPHAB factor 1 easy listening scores ($n = 113$). Factor 1 hearing aid benefit was better for subjects with higher prefitting expectations and for subjects using multiple-memory or multiple-frequency channel hearing aids. Part-time workers had higher easy listening scores than full-time workers, but there was no difference between those in paid work and those not working outside the home. The effect of hearing aid technology on hearing aid outcome is illustrated in Table 3.

The relationship between employment status and age and between age and hearing loss was investigated to explore why employment status affected MAPHAB factor 1 benefit. There was a difference in the average age of the three employment groups ($F[2,155] = 45.1, p < .0001$). Part-time workers were older on average than full-time workers (66.7 vs 56.4 years on average), but subjects not employed outside the home were the oldest (mean = 73.7 years). As expected, hearing loss increased with age ($F[2,145] = 3.87, p = .02$). Thus, part-time workers ($n = 13$) were older and had greater hearing loss than full-time workers ($n = 25$), who were younger and less hearing impaired on average than the largest group of subjects who were not employed ($n = 120$).

Prefitting expectations ($F[1,80] = 4.33, p = .04$) and use of WDRC hearing aids ($F[1,80] = 5.18, p = .03$) affected MAPHAB factor 2 difficult listening scores ($n = 105$). Greater hearing aid benefit for difficult listening situations was associated with better expectations and with use of WDRC. There was also a trend toward greater benefit in difficult listening situations with use of multiple-memory hearing aids ($F[1,80] = 3.48, p = .07$).

No factors were found to significantly influence MAPHAB factor 3 benefit, listening to aversive sounds ($n = 109$). There was, however, a trend of better factor 3 benefit (i.e., aided sounds less aversive relative to unaided) associated with use of multiple-memory aids ($F[1,84] = 3.77, p = .06$).

**DISCUSSION**

**Hearing Aid Use Time**

The majority of subjects reported using their hearing aids for over 4 hours per day. This is consistent with the findings of previous studies in New Zealand (Jerram and Purdy, 1997; Purdy and Jerram, 1998) and North America (Cox and Gilmore, 1990; Cox and Rivera, 1992; Cox and Alexander, 1995; Humes et al, 1996). Based on his extensive MarkeTrak IV survey of hearing aid users, Kochkin (1995) concluded that daily hearing aid use of 4 hours or more is an indicator of hearing aid success. Some hearing aid
### Table 3  Means and SDs for Satisfaction and MAPHAB Factors 1, 2, and 3 Benefit for the Different Hearing Aid Technologies Used by Subjects in the Study

<table>
<thead>
<tr>
<th>Technology</th>
<th>n</th>
<th>Satisfaction Mean (SD)</th>
<th>Factor 1 Mean (SD)</th>
<th>Factor 2 Mean (SD)</th>
<th>Factor 3 Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WDRC</td>
<td>88</td>
<td>15.2 (3.6)</td>
<td>24.4 (21.4)</td>
<td>26.3 (18.4)</td>
<td>-5.8 (25.2)</td>
</tr>
<tr>
<td>Other C</td>
<td>53</td>
<td>15.1 (3.2)</td>
<td>23.6 (24.3)</td>
<td>25.3 (18.5)</td>
<td>-5.1 (24.5)</td>
</tr>
<tr>
<td>PC</td>
<td>6</td>
<td>15.1 (2.8)</td>
<td>16.8 (34.8)</td>
<td>18.6 (33.4)</td>
<td>2.78 (18.8)</td>
</tr>
<tr>
<td>Multiband</td>
<td>68</td>
<td>14.8 (3.5)</td>
<td>27.6 (20.5)</td>
<td>25.5 (17.3)</td>
<td>-3.6 (26.0)</td>
</tr>
<tr>
<td>Multiple memory</td>
<td>35</td>
<td>15.9 (2.9)</td>
<td>19.7 (25.5)</td>
<td>24.5 (17.2)</td>
<td>-2.7 (23.5)</td>
</tr>
<tr>
<td>Multiple microphone</td>
<td>15</td>
<td>16.3 (3.7)</td>
<td>28.1 (20.6)</td>
<td>20.1 (12.3)</td>
<td>-12.3 (17.9)</td>
</tr>
</tbody>
</table>

To enable comparison with Table 2, data presented are for subjects who completed at least 80% of the MAPHAB (n = 146). Other C = other compression circuits (input or output).

users with very specific and limited hearing aid listening needs may be successful users, however, despite using their aids very little. Self-reporting of hearing aid use can be misleading (Humes et al, 1996; Taubman et al, 1999), since subjects tend to exaggerate actual hearing aid use time. Despite this limitation, self-report of hearing aid use appears to be a valuable and widely recognized dimension of hearing aid outcome (Humes, 1999).

### Hearing Aid Benefit

Hearing aid benefit was measured using the MAPHAB (Purdy and Jerram, 1998). As seen previously, benefit was slightly greater for difficult than for easy listening situations (e.g., Cox and Alexander, 1995; Valente et al, 1995, 1998). Studies investigating older versus newer hearing aid technologies typically report mean APHAB benefit values in the range of 20 to 35 percent for the three APHAB listening subscales (e.g., Valente et al, 1995, 1998; Preves et al, 1999), although, occasionally, benefit over 40 percent is obtained. Mean benefit scores for the easy and difficult listening factors in the present study fall within the range of values previously reported, despite the use of a different scale.

Many subjects were unable to complete the MAPHAB. We have noted previously that older clients in particular may have difficulty with some of the APHAB questions (Purdy and Jerram, 1998). The reversal of a number of the items to prevent bias is one source of confusion (Noble, 1998), and our use of a more detailed 100-point scale also may have made the questionnaire too complex for some clients. A recent study showed that, based on respondent preference and test-retest reliability, a 10-point scale is optimal (Preston and Colman, 2000).

As seen in other studies (Cox and Alexander, 1995; Valente et al, 1995, 1998; Preves et al, 1999), hearing aids were not beneficial for listening to aversive environmental sounds. The amount of “negative benefit” was considerably less, however, than values reported previously, presumably reflecting the greater loudness comfort provided by the WDRC technology that the majority of subjects were using. WDRC has gained popularity because it provides better speech intelligibility in quiet compared with linear amplification (Humes et al, 1999; Walden et al, 1999) and greater listening comfort across a wide range of situations (Jenstad et al, 1999). Superior performance has not been found consistently in noisy environments, however (Kam and Wong, 1999; Souza and Turner, 1999).

Previous studies have shown that the APHAB can distinguish between different types of high-performance hearing aids (Valente et al, 1995, 1998; Arlinger et al, 1998; Berninger and Karlsson, 1999; Preves et al, 1999). Consistent with Kochkin’s (1996, 2000) reports of the listening advantages provided by higher-performance hearing aids, benefit was significantly greater in easy listening situations for multiple-memory and multiple-channel hearing aids. This is not surprising, since these technologies allow greater fitting and user flexibility. Benefit in difficult listening situations was greater for WDRC hearing aids. Although some studies have failed to find speech reception benefits of WDRC in noise (Kam and Wong, 1999; Souza and Turner, 1999), other studies have seen WDRC advantages in noise compared with linear technology (e.g., Humes et al, 1999). In the present study, it is possible that clients using WDRC hearing aids experienced greater hearing aid benefit in difficult listening situations because of the way their audiologists selected the
technology. Clients using WDRC had milder hearing losses (by 5 dB on average) than clients fitted with non-WDRC aids; thus, they may have experienced greater benefit in noise due to having less cochlear pathology. The advantages of multiple-microphone hearing aids in noise are well documented and have been demonstrated using the APHAB (e.g., Valente et al., 1995; Preves et al., 1999). Therefore, it was surprising that multiple-microphone technology was not a predictor of MAPHAB factor 2 benefit. This could be due to the small number of subjects fitted with multiple-microphone hearing aids. It is also possible that audiologists only prescribed this technology for clients with more severe speech in noise problems.

**Satisfaction**

In general, the subjects were very satisfied with their hearing aids. The mean rating of 76 percent was slightly higher than the value of 71 percent found by Purdy and Jerram (1998) using the same scale. Subjects in the present study had new hearing aids, and there was a relatively high proportion of high-performance hearing aids fitted. Kochkin (1995, 1996) found that satisfaction is greater for newer hearing aids and newer technologies. Mean scores reported by Cox and Alexander (1999) for the Satisfaction with Amplification in Daily Living (SADL) ranged from 43 to 91 percent for the individual items in their satisfaction profile. Although derived in quite different ways, the 70 percent global satisfaction value obtained by Cox and Alexander for the SADL questionnaire and Kochkin’s (1996) reported satisfaction values of 71 to 75 percent for new and high-performance hearing aids are consistent with the satisfaction results obtained in the present study.

There were statistically significant positive correlations between satisfaction and the two MAPHAB listening factors. Similar to Purdy and Jerram (1998), the strongest correlation between hearing aid benefit and satisfaction was for difficult listening situations, and satisfaction was higher in subjects who wore their aids more often. This is consistent with Kochkin’s (1993, 1996) finding that satisfaction is highly related to the number of listening situations in which the wearer’s needs are met. Kochkin (1999, 2000) has used the term “multiple environmental listening utility” (MELU) concept, users of multiple-memory hearing aids were significantly more satisfied with their hearing aids.

Hyde and Riko (1994) criticized global measures of overall satisfaction on the basis that they confound features of hearing aid performance, convenience, aid physical characteristics, and stigma. This could explain why only one of the factors investigated (multiple memories) was predictive of satisfaction. Future research in this area may be more successful if a more specific, differentiated satisfaction scale such as the SADL (Cox and Alexander, 1999) is used.

**Demographic Factors**

Part-time workers had higher easy listening hearing aid benefit scores than full-time workers. This is probably explained by the greater degree of hearing loss seen in older subjects, who made up the majority of part-time workers. Previous hearing aid experience (Parving and Philip, 1991), age (Mulrow et al., 1992; Crowley and Nabelek, 1996; Jerram and Purdy, 1997), and degree of hearing loss (Brooks, 1985; Kochkin, 1995) have been found previously to affect hearing aid outcome but were not significant factors in the present study. Differences in subject groups across studies could account for these differences.

**Attitudes**

With the exception of one item, internal reliability of the HARQ hearing aid stigma factor was very good, as was found by Hallam and Brooks (1996). Hallam and Brooks (1996) also obtained a relatively low item loading for item 9, which was excluded from the present analysis. In contrast to previous studies (Hickson et al., 1986, 1999; Brooks, 1989; Brooks and Hallam, 1998), attitudes toward hearing aids were not predictive of hearing aid outcome. Brooks (1989) investigated attitude with a single question that was similar in content to item 9 of the HARQ, and found that subjects with a more positive attitude wore their hearing aids more when they were evaluated 4 months after the fitting.

Brooks and Hallam (1998) assessed attitudes to hearing loss and hearing aids using the 40-item HARQ, which has seven subscales, including the Hearing Aid Stigma subscale used in the present study. In agreement with the present study, an attitude that wearing a hearing aid is stigmatizing was not predictive of hearing aid outcome. Attitudes to hearing loss and
hearing aids measured by other subscales (feelings of personal distress/inadequacy due to hearing loss, minimization of hearing impairment, and not wanting/need hearing aids) were predictive of outcome. Two of these factors (distress/inadequacy and minimization) are similar in content to the CPHI personal adjustment subscales. Stigma associated with hearing loss and hearing aids is a barrier to hearing aid use (Kochkin, 1993; Hétu, 1996; Arnold and MacKenzie, 1998). Hétu (1996) has shown that adults who develop a hearing loss are reluctant to acknowledge hearing difficulties because of fear of stigmatization and embarrassment. The finding of no relationship between the perception of hearing aids as stigmatizing and hearing aid outcome suggests that, in general, individuals who accept hearing aids have generally overcome this fear. The range of responses to the HARQ (see Table 1) indicates that some individual subjects did have very poor attitudes toward hearing aids; thus, for some subjects, concerns about stigma may have still been a problem.

**Expectations**

The poor internal reliability of the 12 items of Seyfried’s (1990) expectations questionnaire also was seen by Bentler et al (1993). We were not able to replicate the good reliability reported by Bentler et al for a subset of five expectations items and instead obtained moderately good reliability for a different subset of nine items.

Higher prefitting expectations were associated with higher daily hearing aid use time. Expectations also influenced hearing aid benefit in easy and difficult listening situations. On average, subjects had positive expectations (mean = 2.3 ± 0.6). The mean expectations score plus 1 SD falls in the middle of the 6-point scale. An expectations score greater than 3, indicating low expectations, could be used as an indicator for a potentially poorer outcome. Further research is needed to determine whether additional prefitting counselling (e.g., Brooks, 1979, 1983; Brooks and Johnson, 1981) would improve hearing aid outcomes for these individuals with low expectations.

Higher expectations scores predicted greater hearing aid benefit in noisy and in quiet listening situations. In contrast, Schum (1999) found a modest negative correlation between prefitting expectations measured using the Hearing Aid Needs Assessment questionnaire and speech in noise scores on the Hearing Aid Performance Inventory (HAPI, Walden et al, 1984). Thus, in contrast to the present study, higher expectations of listening performance were associated with poorer listening outcome. Seyfried (1990) found no relationship between expectations (measured using Bentler et al’s [1993] subset of items) and hearing aid benefit measured using the Understanding Speech subsection of the Hearing Performance Inventory (HPI, Giolas et al, 1979). The HAPI and HPI directly assess aided performance and thus differ from the subtractive benefit measure obtained using the MAPHAB in the present study. Another difference between studies is that Schum only examined expectations of aided listening ability, whereas Seyfried’s expectations questionnaire assesses a range of expectations including the ability to handle hearing aids and physical comfort.

**Personal Adjustment**

As has been found previously (Demorest and Erdman, 1987, 1989; Jerram and Purdy, 1999), the CPHI Acceptance of Loss, Stress, and Denial subscales had excellent internal reliability. Acceptance of Loss subscale scores were related to hours of use. Crowley and Nabelek (1996) also found a predictive relationship between CPHI Personal Adjustment scores (13 subscales including Acceptance of Loss) and hearing aid performance. Although hearing aid performance and hours of use are not the same, they are related (Purdy and Jerram, 1998). The original CPHI is a very long questionnaire that examines many aspects of hearing loss (Demorest and Erdman, 1986). Using the whole scale, Cox and Rivera (1992) found no relationship between CPHI and PHAB results. This is consistent with our findings of no relationship between MAPHAB benefit and CPHI Acceptance of Loss, Stress, or Denial scores.

A high CPHI score indicates good personal adjustment to hearing loss. Thus, the mean score of 3.7 ± 1.3 for the Acceptance of Loss scale indicates that the subjects in this study were generally “well adjusted” to their hearing loss. This is probably not surprising for subjects who were willing to participate in hearing aid research requiring a reasonable time commitment, some of whom had worn hearing aids previously. Similar Acceptance of Loss scores have been reported in other studies (Demorest and Erdman, 1989; Cox and Rivera, 1992; Garstek and Erler, 1998; Erdman and Demorest, 1998; Jerram and Purdy, 1999). Forty-four percent of subjects had low Acceptance of Loss scores of 2 or less. Pre- and/or postfitting counselling
might improve hearing aid outcomes for these individuals (Brooks, 1989).

**SUMMARY AND CONCLUSIONS**

This study evaluated the effects of a number of predictor variables on three measures of hearing aid outcome, hours of use, subjective benefit, and overall satisfaction. Subjects completed three questionnaires prior to hearing aid fitting that examined personal adjustment to hearing loss, attitudes to hearing aids, and expectations of hearing aids. These questionnaires had good internal reliability after exclusion of some items from the attitudes and expectation scales. On average, subjects had a moderate level of personal adjustment and positive attitudes and expectations, but there was considerable variability across individuals. Subjects were generally satisfied with their hearing aids and had good subjective benefit. The majority of subjects reported using their aids more than 4 hours per day. Subjects who used their aids more had higher benefit and satisfaction ratings. Satisfaction was related to benefit, particularly for difficult listening situations.

Demographic factors did not affect hearing aid outcome. Multiple-memory hearing aids increased satisfaction and benefit. Multiple-channel and WDRC instruments were associated with greater hearing aid benefit, but the WDRC effect may have resulted from audiologists using WDRC in subjects with lesser degrees of hearing loss. On average, satisfaction was highest for multiple-microphone aids, but this effect was not significant, presumably due to the small number of subjects fitted with this technology. The results support the use of newer hearing aid technologies in order to maximize hearing aid outcomes.

Subjects with better prefitting expectations of hearing aids and better personal adjustment to hearing loss measured using the CPHI Acceptance of Loss subscale used their hearing aids more. Expectations also positively influenced benefit in easy and difficult listening situations. The predictive influence of prefitting expectations and acceptance of hearing loss on hearing aid use and benefit suggests that these factors should be regularly assessed prior to hearing aid fitting. Prefitting and follow-up counselling may be beneficial in cases where expectations of hearing aids and acceptance of hearing loss are poor.

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APPENDIX

Seyfried (1990) Expectations Checklist

1. I will have difficulty operating the controls on my hearing aid(s).
2. My hearing aids will fit comfortably.
3. My hearing aids will make speech more distinct.
4. My family believes my hearing aids will help me communicate better.
5. I will have difficulty inserting and removing my hearing aid(s).
6. I will adjust slowly to my hearing aids.
7. In some noisy situations, my hearing aids will be helpful.
8. I will need my hearing aids in most listening situations in which I find myself.
9. When I am using my hearing aid(s), I will need to watch speakers’ faces and ask them for repetitions occasionally.
10. When I am speaking to others in a quiet room, my hearing aid(s) will be helpful.
11. When I am using my hearing aid(s), some sounds will be uncomfortably loud.
12. I will feel self-conscious when I am wearing my hearing aids.

Hearing Attitudes in Rehabilitation Questionnaire (HARQ)

1. I think that if you wear a hearing aid people tend to ignore you.
2. I would stand out in a crowd wearing a hearing aid.
3. Many people don’t know how to react to you when you have a hearing aid.
4. It would make me feel old to wear a hearing aid.
5. If I wear a hearing aid, people will probably think I’m a bit stupid.
6. It would embarrass me to have to wear a hearing aid.
7. I think people react differently to you when you are wearing a hearing aid.
8. From what I know, hearing aids don't help a great deal.
9. I think the behind-the-ear aids are really quite small and inconspicuous.

Communication Profile for the Hearing Impaired (CPHI) Subscales

(Items 1–9 = Acceptance of Loss, 10–17 = Stress, 18–25 = Denial)

1. I try to give the impression of normal hearing.
2. I try to hide my hearing problem.
3. Sometimes I'm ashamed of my hearing problems.
4. I'm sensitive about my hearing loss.
5. I find it difficult to admit to others that I have a hearing problem.
6. It bothers me to admit that I have a hearing loss.
7. I can't talk to people about my hearing loss.
8. I have a hard time accepting the fact that I have a hearing loss.
9. I'd rather miss part of a conversation than admit that I have a hearing loss.
10. I feel threatened by many communication situations due to difficulty hearing.
11. I'm not very relaxed when conversing with others.
12. I'm not very comfortable in most communication situations.
13. I get very tense because of my hearing loss.
14. When I have trouble hearing, I become nervous.
15. I worry about looking stupid when I can't understand what someone has said.
16. Straining to hear upsets me.
17. When I can't understand what's being said, I feel tense and anxious.
18. Sometimes I feel left out when I can't follow the conversation of those I'm with.
19. I sometimes get annoyed when I have trouble hearing.
20. When I have trouble hearing, I feel frustrated.
21. It's frustrating when people refuse to repeat what they've said.
22. Sometimes when I misunderstand what someone has said, I feel foolish.
23. I sometimes get angry with myself when I can't hear what people are saying.
24. Sometimes I feel tense when I can't understand what someone is saying.
25. I sometimes feel embarrassed when I misunderstand what someone has said.