Personality, Hearing Problems, and Amplification Characteristics: Contributions to Self-Report Hearing Aid Outcomes

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Objective: **When we evaluate the success of a hearing aid fitting, or the effectiveness of new amplification technology, self-report data occupy a position of critical importance. Unless patients report that our efforts are helpful, it is difficult to justify a conclusion that the intervention has been successful. Although it is generally assumed that subjective reports primarily reflect the excellence of the fitted hearing aid(s) within the context of the patient's everyday circumstances, there is relatively little research that assesses the validity of this assumption. In previous work, we have reported some contributions of the service delivery setting (private practice versus public health) to self-report outcomes. The purpose of the present investigation was to assess the relative contributions of patient variables (such as personality and hearing problems) and amplification variables (such as soft sound audibility, gain and maximum output) to self-reports of hearing aid fitting outcomes.**

Design: **A cross-sectional survey of 205 patients was conducted with cooperation of eleven Audiology clinics. All subjects were recruited when they were seeking new hearing aids. Before the hearing aid fitting, measurements of personality and response bias were made, as well as measures of hearing problems and expectations about amplification. At the fitting, traditional verification data were measured including sound field thresholds, preferred gain for conversation, and maximum output. Six months after the fitting, a set of 12 standardized self-report outcomes was completed. Analyses concerned: (1) the associations among personality, response bias, and self-reports about hearing problems that are available before the hearing aid fitting, and (2) the associations of these precursor variables, and fitting verification data, with self-report data assessing the outcome of hearing aid provision.**

Results: **Self-reports of hearing problems, sound aversiveness, and hearing aid expectations obtained before the fitting were found to be more closely related to the strength of certain personality traits than to audiometric hearing loss. Response bias also was associated with personality variables. Analyses of the collection of outcome measures produced a set of three components that were interpreted as a Device component, a Success component, and an Acceptance component. The Device component was construed as reflecting characteristics of the hearing aid whereas the two other components were construed as reflecting attributes of the wearer. The Success and Acceptance components were each significantly associated with several personality traits, but the Device component was not associated with personality. Variables available before the fitting accounted for 20 to 30% of each outcome component whereas amplification variables measured to verify the fitting accounted for only 10% on only one component.**

Conclusions: **As reported in previous research, personality is associated with self-report outcome data. However, if practitioners utilize existing measures of hearing problems at the prefitting stage, separate personality data will not yield additional leverage in prediction of long-term fitting outcomes. Traditional fitting verification data as measured in this study, proved minimally useful in prediction of long-term outcomes of the fitting. A large proportion of variance in self-report fitting outcomes has yet to be accounted for. Finally, it appears that certain types of questionnaires might be more appropriate for research evaluating new amplification devices, whereas a different questionnaire approach might be optimal for evaluating intervention effectiveness in a clinical context.**

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Self-report outcome data, usually from standardized questionnaires, provide a measure of the daily life impact of hearing aid provision from the patient's point of view. Indeed, because each individual has a unique mélange of life circumstances and auditory requirements, it is arguable that self-report data provide the only ultimate test of device effectiveness. For the most part, practitioners and researchers tend to assume that self-report outcome data primarily reflect the excellence of the fitted hearing aid(s) within the context of the patient's everyday circumstances, although there is relatively little research that assesses the validity of this assumption. It is plausible that variables other than those comprising the amplification system might influence subjective outcomes of hearing aid provi-

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sion, but there has been limited exploration of the extent to which this occurs. Nevertheless, despite the limitations in the research base for self-report outcomes data, they have quickly become a powerful force in determining the effectiveness of amplification in research and clinical settings. Further, with the current impetus toward evidence-based practice in hearing aid provision, self-report outcomes data have become even more influential because they are used to support the inclusion or exclusion of approaches to rehabilitation.

Although there is no denying that self-report data from standardized questionnaires occupy a key position in hearing health care, several aspects of these types of data are not well understood. For example, the context within which amplification is delivered (private practice, public health, or a private-public partnership) might exert a significant influence on subjective fitting outcomes. We have explored this variable in previous work looking at private practice versus public health (VA) systems in the United States (Cox, Alexander & Gray, 2005a), and it is not further considered in this article. Another potentially important element that has not been fully explored is the impact of patient personality. Reports from a variety of health care fields have demonstrated associations between personality and responses to questionnaires (e.g., Chou & Brauer, 2005; French et al., 2000). In hearing health care, personality effects can be seen in patient's subjective reports about the extent to which hearing problems limit and circumscribe their life's quality and scope (e.g., Gatehouse, 1990; Saunders & Cienkowski, 1996). More specifically, in the amplification literature, several researchers have noted that personality attributes can account for 10 to 30% of the variance in responses to some questionnaires that assess such hearing aid outcomes as benefit and satisfaction (e.g., Barry & Barry, 2002; Cox, Alexander, & Gray, 1999; Gatehouse, 1994; Hutchinson, Duffy, & Kelly, 2005).* Even so, the extent and direction of relationships between patient personality and specific measures of hearing aid fitting outcomes have not been established.

Blending of personality effects into self-report outcome data is not necessarily a bad thing. When self-report data are used to evaluate the outcome of hearing aid provision in terms of the extent to which it has addressed the problems of the patient, the influence of patient personality on the data is a natural and desirable feature, because one is seeking the result through the eyes of this specific patient. On the other hand, if the goal is to use self-report data to compare the technical features of different devices, or to assess the excellence of the amplification device in the absence of patient variables or rehabilitative context variables, the influence of patient personality potentially introduces a nuisance variable that could complicate data interpretation and limit generalizability of findings (the extent to which this occurs would depend on the research design). To address this matter, it would be useful to know the magnitude of personality effects and whether personality is expressed to the same extent in most questionnaires, or whether some questionnaires are less influenced than others by personality attributes.

Another matter that concerns many practitioners and researchers is the potential influence of socially correct responding on answers to questionnaire items about hearing aid outcomes. It is sometimes speculated that listeners who are unduly influenced by a desire to appear "good" or "proper" might not be fully candid in their responses, especially if their opinions are negative. This could result in overly favorable self-report data. However, there is little research examining this response bias variable or assessing its import on self-report data regarding hearing aid outcomes.

Despite concerns about the underlying bases and motivations of self-report, these types of data will continue to play a critical role in quantifying hearing aid outcomes because there are no surrogate variables with established validity for measuring real-world effectiveness of hearing aid provision. Thus, there is a need to develop a more complete understanding of the hearing-aid and non-hearing-aid variables that might affect self-report data as applied to hearing aid outcomes. This article addresses that need. It reports an investigation that explored two themes: (1) the associations between personality, response bias, and self-reports about hearing problems that are available before the hearing aid fitting; and (2) the associations of these precursor variables, and verification data, with self-report data assessing the outcome of hearing aid provision.

The study extended previous research in several directions. Evidence indicates that data in different subjective outcome domains are not always consistent, suggesting that the apparent outcome of hearing aid provision might depend partly on the questionnaire used to measure it (e.g., Gatehouse, 1994; Humes, Garner, Wilson, & Barlow, 2001). This result disappoints some users of self-report data, but it is actually not surprising, because seemingly small differences in

*To put this modest relationship in perspective, it is helpful to note that aspects of personality have been found to be as effective as audiogram-based hearing impairment or speech understanding data in accounting for variance in subjective hearing aid benefit or satisfaction (e.g., Gatehouse, 1994; Cox et al, 1999; Walden & Walden, 2004).

format and wording of items can produce substantial changes in responses (e.g., Schwarz, 1999; Sudman & Bradburn, 1982). To assess the likely functional impact of this issue in current practice, outcomes were measured using several widely applied standardized questionnaires.

In addition, previous research on this topic has not had access to data describing the characteristics of amplification used by subjects. As a result, it has not been possible to explore the extent to which differences in outcomes might be due to amplification variables. To address this point, the research tracked several characteristics of the fitted hearing aids. This permitted the assessment of the extent to which amplification particulars contributed to variance in subjective outcomes. Other refinements included the use of a personality measure that is intended to describe variations in normal personality rather than psychopathology, and exploration of the predictive power of previous hearing aid experience, patient expectations, and subjective hearing problems, as well as type of service setting (public health or not).

The investigation was designed to monitor hearing aid wearers from their first inquiry about a new hearing aid through a 6-mo follow-up period. Prefitting self report data were obtained about personality and other subjective variables that might plausibly be modulated by personality (response bias, hearing disablement [see definition below], and expectations). Technical properties of the hearing aid fittings were documented. Finally, after 6 mo of hearing aid use, self report outcomes were measured in a variety of outcome domains and using an extensive battery of measures. In addition to exploring the relationships between personality and other variables more commonly encountered in hearing aid fitting, the study was intended to address the following specific questions:

1. How much of the variance in long-term subjective outcomes of a hearing aid fitting can be accounted for by subject variables that can be measured before the fitting, such as hearing impairment, hearing problems, expectations, personality and response bias?
2. How much of the variance in long-term subjective outcomes of a hearing aid fitting can be accounted for by objective data about the specific amplification system used by the patient?
3. Are some approaches to assessment of self-report outcomes (domains or questionnaires) less associated with subjective patient attributes, and thus perhaps more suitable for applications that attempt to evaluate or compare amplification devices independent of patient/environmental variables?

METHODS

It was considered important to recruit participants who were bona fide clinical patients rather than research volunteers solicited for the study who might not have the same commitment to the hearing aid fitting. Further, to preserve the validity of the clinical process, the protocol was designed to disrupt clinical services as little as possible while remaining consistent with the requirements of research rigor. Participants were individuals who presented seeking hearing aids at one of eleven Audiology clinics. Five clinics were located in VA Medical Centers in Florida, Washington State, Washington, DC, and East and West Tennessee. Five clinics were typical private practice (PP) establishments situated in Tennessee, Texas, Ohio, Florida, and California. One site was a university-based clinic in Tennessee where patients pay for hearing care at rates similar to some free-standing dispensaries. The recruitment of subjects from multiple sites distributed across the country was intended to produce a subject pool that would be widely representative, and not limited to any particular geographical location or cultural subgroup. This has the advantage of yielding results with high face validity for US hearing aid seekers in general.

Subjects

There were 205 subjects, 158 men and 47 women. Figure 1 depicts their composite audiograms, including thresholds of both ears for all subjects. The average woman subject had less high-frequency hearing loss than the average man, which is consistent with the patterns reported by Jerger et al. (1993) for audiograms of older men and women. The average age of the men was 73 years (SD = 7.5; range, 41 to 87). The average age of the women was 75 years (SD = 7.0; range, 64 to 95). There were 139 subjects from VA clinics and 66 from non-VA clinics.

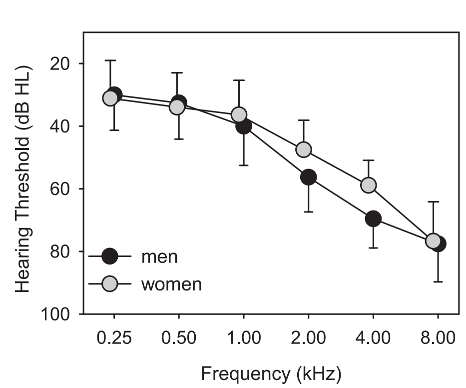

Fig. 1. Composite audiograms including thresholds for both ears for 158 men and 47 women subjects. Bars show 1 standard deviation.

TABLE 1. Brief description of qualities associated with each of the five personality traits measured using the NEO-FFI questionnaire

Trait	High scorer	Low scorer
Neuroticism	Experiences negative emotions such as anger, embarrassment and guilt	Copes well with stress. Relaxed and calm
Extraversion	Enjoys other people. Outgoing, enthusiastic, optimistic, and self-confident	Reserved and independent
Openness	Intellectually curious, aesthetically sensitive, insightful, broad-minded, flexible	Pragmatic, conforming and conventional. Prefers the routine and familiar
Agreeableness	Trusting, warm-hearted, peace-loving, sympathetic, and helpful to others	Skeptical, assertive, suspicious, and argumentative
Conscientiousness	Plans and carries out activities in an organized, methodical, thorough way	Impatient, careless and absent-minded

Inclusion criteria were: bilateral, symmetrical, sensorineural, mild to moderately-severe hearing impairment; sufficient vision and reading ability to comprehend and respond to the questionnaires; generally good health (adequate to participate in a 7- to 8-mo experiment); at least 60 years old*; and non-institutionalized living status. Forty-two percent of the subjects were previous hearing aid users, the rest were acquiring their first hearing aid.

A total of 230 subjects were initially enrolled in the study and completed the prefitting questionnaires. Twenty-five of these dropped out before the end: nine decided not to obtain hearing aids after all or returned them during the trial period, eight kept the hearing aids but did not return the 6-mo outcomes data, six were dropped for inadvertent protocol violations, and two terminated because of illness. None of the VA subjects paid anything for hearing aid services or devices. Among the non-VA subjects, three reported that a third party had paid the full cost of the hearing aid devices and services, and 11 more reported that a third party paid at least some of the cost of the devices and services.

Procedure

Recruitment • In a given week, the first patient who met the inclusion criteria was invited to participate in the research. If that individual declined, the next eligible patient was invited to participate, and so on. The actual day of subject enrollment varied across the week. No more than one new subject per week was recruited at each site. Participation rate was about 85%. Each subject completed questionnaires both before and after the hearing aid fitting.

Prefitting Questionnaires

A potential subject experienced a history interview, audiometric testing, informational counseling about the hearing impairment and an estimate of the appropriateness of obtaining amplification. Then, if the decision was made to obtain new hearing aids, and the subject signed the informed consent for the study, the prefitting questionnaires were completed by the subject in the office before further counseling was provided by the audiologist. The questionnaires included measures of personality, response bias, hearing aid expectations, and hearing disablement. The term disablement encompasses both activity limitations and participation restrictions as defined by the International Classification of Functioning, Disability and Health (ICF, 2001). Activity limitations are the difficulties the hearing-impaired person has in performing everyday hearing-related tasks such as understanding speech, localizing sounds, etc. Participation restrictions are the problems or barriers the hearing-impaired person encounters that circumscribe his/her opportunities for involvement in the situations of daily life. They can include such things as partaking in church services or feelings of embarrassment at bridge club meetings. The details of activity limitations and participation restrictions experienced by a specific patient will differ across individuals, depending on the demands of that person's lifestyle, and variables such as age, cultural factors, social factors, and gender.

Additional prefitting questionnaires addressed variables of locus of control, coping strategies, and general subjective health. These data have been examined elsewhere for their value as potential predictors of hearing aid seeking behavior (Cox, Alexander, & Gray, 2005b), and are not treated further in this article. All of the prefitting questionnaires except response bias have been described in considerable detail in other publications (Cox, et al. 2005a; 2005b). Consequently, their description here is relatively brief. The entire set of prefitting questionnaires required about 60 to 90 minutes to complete.

- Personality was assessed using the 60-item NEO Five-Factor Inventory (Costa & McCrae, 1992). The NEO-FFI provides a measure of five person-

*Because of an error, 8 subjects younger than 60 were included.

ality traits, or dimensions: Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness. Table 1 provides a brief description of some of the characteristics of each trait. These dimensions have recently been recognized by many psychologists as encompassing the major domains of personality in a wide variety of cultures (McCrae & Costa, 1997). For a given individual, the pattern of traits remains essentially constant across the adult life span (Costa & McCrae, 1997). Evidence indicates that the five-factor model of personality is a valid and comprehensive approach to assessment of variations in normal personality. Thus, it is ideally suited for use in studies of the relationships between personality and other phenomena in individuals who do not have psychopathology.

- Response bias was defined in this study as a tendency of subjects to respond to questions in a way that represents them in a favorable light. Although this variable has been found to affect responses to personally threatening questions, it was not known whether it has a notable influence in responses to hearing-related questionnaires (which are generally not personally threatening). Bias was assessed using a five-item measure of socially correct responding (Hays et al., 1989). The five items were appended to the NEO-FFI in the same format so that they blended into it. The items are reproduced in the Appendix.
- Expectations about the hearing aid(s) were quantified with the global expectation score produced by the 15-item Expected Consequences of Hearing Aid Ownership (ECHO) scale (Cox & Alexander, 2000). One ECHO item addresses the cost of the hearing aids. This item was omitted for any subject whose hearing aids were fully or partly subsidized by a third party.
- Participation restriction in unaided listening was quantified using the Total score produced by the 25-item Hearing Handicap Inventory for the Elderly (HHIE) (Ventry & Weinstein, 1982).
- Activity limitation in unaided listening was measured using the 18-item Global speech communication score (mean of EC, RV, and BN scores) produced by the Abbreviated Profile of Hearing aid Benefit (APHAB) (Cox & Alexander, 1995).
- Sound Aversiveness in unaided listening was measured with the 6-item Aversiveness (AV) subscale of the APHAB.
- A generic measure of hearing disablement was obtained using the single item query: "What is your degree of hearing difficulty without wearing a hearing aid?" Potential responses were: none, mild, moderate, moderately-severe, and severe. This variable is labeled Degree-Unaided-Difficulty.

TABLE 2. Summary of characteristics of fitted hearing aids

Hearing aid characteristic	% of patients
Wide dynamic range compression (2 kHz knee point <65 dB SPL)	50
Midrange compression (2 kHz knee point = 65 to 80 dB SPL)	20
Compression limiting (2 kHz knee point >80 dB SPL)	20
Different compression category in left and right ears	10
Behind the ear (BTE)	10
In the ear (ITE)	46
In the canal (ITC)	27
Completely in canal (CIC)	17
Unilateral fitting	5
User volume control	59
Telecoil	20
Multichannel	19
Directional microphone	29
Programmable analog	88
Programmable digital	12

Data are in percentages.

Hearing Aid Fitting

Hearing aids were fitted after completion of the prefitting questionnaires. All subjects were fitted using programmable devices having similar processing options. The fittings were completed in the years 2000 to 2003, and the devices were current at that time. It was not practical to attempt to standardize the make and model of the fitted hearing aids, nor did there seem to be any compelling scientific reason to do so (e.g., Humes et al., 2004; Larson et al., 2000). The general guidelines for the study called for hearing aids in the case style judged most appropriate for the patient. All devices had the capacity to be fitted as wide dynamic range compression (WDRC) processors, but fine tuning adjustments of compression parameters were permitted. Bilateral fittings were preferred but unilateral fittings were permitted. Of the 205 subjects, non-systematic technical problems resulted in at least one missing piece of technical data for 39 subjects. Table 2 summarizes the known data on hearing aid features of the fitted hearing aids.

After fine tuning, volume/gain controls were adjusted by the audiologist, in consultation with the subject, to achieve a comfortable listening level for conversational speech presented at 65 dB SPL in a moderately reverberant room.* The fittings were then documented as follows:

- Audibility of soft sounds was assessed using aided sound field thresholds for warble tones. The research protocol called for disabling any feedback

*Patients with previous hearing and experience used a criterion of "comfortably loud" to judge the appropriate gain setting. Patients receiving their first hearing aids used a criterion of "comfortable but slightly loud" for this adjustment.

management or noise reduction features for warble tone threshold measures. Low-frequency audibility was represented as the average of thresholds at 250 Hz and 500 Hz. High-frequency audibility was represented as the average of thresholds at 2000 Hz and 4000 Hz.

- Preferred gain for conversational speech was assessed by computing the ratio of average preferred coupler gain at 1000, 2000, and 4000 Hz (for input = 65 dB SPL) to average coupler gain prescribed at the same frequencies using the NAL-R prescription procedure (Byrne & Dillon, 1986).
- Level of loud sounds was assessed by computing the difference between the optimum high-frequency average (HFA) OSPL90 prescribed using the NAL procedure (Dillon & Storey, 1998) and the HFA OSPL90 measured in a 2cc coupler for the fitted hearing aids at the preferred gain setting.
- Finally, input/output functions were obtained at the preferred gain setting for 500 Hz and 2000 Hz tones.

After the fitting was completed, subjects were provided with standard, written material covering orientation and adjustment to amplification as well as the verbal orientation and adjustment protocol customarily provided by the dispensing audiologist.

Postfitting Questionnaires

Each of the subjects wore the amplification system for a nominal 6-mo period and then completed the post-fitting set of questionnaires which was mailed to him/her at this time. The post-fitting questionnaires were completed at home and returned by mail. The median interval between fitting and outcome measurement was 188 days. Eighty percent of the subjects completed the post-fitting questionnaires within 202 days of fitting. The remainder took longer as a result of necessary hearing aid repairs or recasing or postage delays.

Subjects were informed that the audiologist who dispensed their hearing aids would not see their responses to the outcome measures. This was done to encourage subjects to be completely candid in their feedback about fitting effectiveness. The outcome domains assessed included: residual problems in performance in daily life, residual problems in participation in daily life, benefit, satisfaction, and use. Some domains were assessed more than once. Overall, twelve measures of self-report outcomes were obtained, as follows:

- Two measures of post-fitting disablement were obtained. Residual problems in participation were measured using the HHIE Total score, completed to describe problems during aided listening. Residual problems in speech communication performance (activity limitations) were measured using the APHAB Global score, completed to describe problems during aided listening.
- Sound Aversiveness in aided listening was measured with the APHAB AV score completed to describe problems with amplified environmental sounds.
- Two types of benefit data were obtained, encompassing exemplars of difference and direct measurements. Difference benefit was defined as the difference between aided and unaided functioning (unaided problems—aided problems). Difference benefit was computed using both the HHIE and the APHAB data. Direct benefit was defined as the magnitude of change produced by the hearing aid, independent of the starting (unaided) and ending (aided) points. The 25-item Shortened Hearing Aid Performance Inventory for the Elderly (SHAPIE Dillon, 1994) provided the measure of direct benefit.
- Two satisfaction questionnaires were administered. Overall satisfaction was quantified using a single item query ("Overall, how satisfied are you with your new hearing aids?"). There were five possible responses: Very satisfied, Satisfied, Neutral, Dissatisfied, Very dissatisfied.
- The 15-item Satisfaction with Amplification in Daily Life (SADL) Scale (Cox & Alexander, 1999; 2001) yielded four satisfaction subscale scores. The four subscale scores were used in preference to a global satisfaction score because the subscales address different components of satisfaction, and are, by design, not strongly related to each other. One of the SADL items addresses the extent to which the hearing aids are worth their cost. This item was omitted for any subject whose hearing aids were fully or partly subsidized by a third party.
- Daily hearing aid use was quantified using a single item that requested the subject to select one of four categories to describe the average number of hours that he/she used amplification each day.

RESULTS

A variety of statistical methods were chosen to evaluate the data. It has been argued in some textbooks that when responses to individual questionnaire items are ordinal in nature, derived scale scores cannot accurately be treated using parametric statistical methods. However, many statistician-scientists do not subscribe to this view (for a review see Velleman & Wilkinson; 1993). In this study, we have followed the position of Nunnally & Bernstein (1994), and used parametric analyses for the data.

Preliminary data screening indicated that some of the prefit and outcome variables were skewed rather than normally distributed. This has the potential to degrade the statistical results under some circumstances (Tabachnick & Fidell, 2001). However, for the analyses and the sample sizes used in this study, it was found that transformations to normalize distributions had minimal or no effect on the statistical results. Based on this consideration and the fact that results with transformed data can be less straightforward to apply, none of the data were transformed in the results reported. Where appropriate, exact probability values are given to facilitate interpretation.

Although 205 subjects returned outcomes data after 6 mo of hearing aid use, not every subject provided usable data for every measure. In the analyses that follow, the number of subjects included is indicated in the figure or table when N is fewer than 205.

VA and private practice (PP) patients were combined for these analyses. In previous evaluations of data collected in the course of this investigation, it has been shown that there are some significant differences in personality traits between VA patients and those from PP sites (Cox et al., 2005b). Further, significant differences were shown between VA and PP patients in some post-fitting outcome measures after three weeks of hearing aid use (Cox et al., 2005a). Based on these findings, one might ask whether it is reasonable to combine VA and PP patients for analysis in this investigation. The rationale for combining the two types of patients rests on the logical assumption that the relationship between personality and self-report outcomes is universal, and is therefore similar across different types of clinical service contexts. The accuracy of this assumption was assessed by comparing the patterns of correlations between personality (N, E, O, A, C) and bias (B) variables and each outcome variable for both types of subjects. To illustrate the process: for a given outcome measure, correlations were computed between the outcome scores and scores for each of N, E, O, A, C, and B. Separate correlations were computed for VA patients and PP patients. This produced six VA-PP pairs of correlation coefficients per outcome measure. Of the twelve outcome measures, six produced at least one statistically significant correlation ($p \leq 0.01$) between the outcome and N, E, O, A, C, or B. To assess the similarity of the patterns produced by VA and PP patients, correlations were computed between the pairs of correlation coefficients for each of these six outcome measures. These correlations of correlation coefficients yielded coefficients ranging from 0.72 to 0.96 with a mean value of 0.86. This result supports the assumption made in this study, namely, when there is a relationship between personality variables and outcome variables, this relationship is similar in VA and PP patients.

TABLE 3. Mean and standard deviation for each of the prefitting variables

Variable name	Mean score	Standard deviation
Neuroticism (NEO-FFI)	48.0	9.8
Extraversion (NEO-FFI)	49.9	9.6
Openness (NEO-FFI)	44.2	8.7
Agreeableness (NEO-FFI)	51.0	10.1
Conscientiousness (NEO-FFI)	49.2	9.1
Response bias	13.2	2.8
Expectations (ECHO)	5.4	0.6
Participation restriction (unaided HHIE)	46.3	23.1
Activity limitation (unaided APHAB Global)	55.9	17.3
Sound aversiveness (unaided APHAB AV)	31.2	20.9
Degree-unaided-difficulty	2.5	0.7

Prefitting Variables

Scoring • Before the hearing aid fitting, both generic variables (Personality and Response Bias) and more traditional hearing-specific variables (Hearing Disablement and hearing aid Expectations) were measured. Table 3 depicts the mean score and variability for each prefitting variable.

- The customary method of scoring the NEO-FFI involves transforming an individual's raw score for each of the five factors into a standardized score format using the equation: Transformed score = 10[(raw score − mean score)/standard deviation] + 50. Transformed scores are interpreted as follows: 45 to 55 = average, 56 to 65 = high, 35 to 44 = low, 66 and higher = very high, 34 and lower = very low (Costa & McCrae, 1992). Although mean NEO-FFI scores are very similar for men and women, there are small gender differences for some traits. As a precaution against any confounding of results with gender effects, the mean scores used in the transformations were the gender-specific means for adult men and women (Costa & McCrae, 1992).
- The score for Response Bias was computed as the sum of responses to the five items. The range of possible scores was 0 to 20. A higher score was indicative of more socially desirable responding.
- The Expectations score was computed as the mean response to all the items of the ECHO questionnaire. The range of possible scores was 1 to 7. A higher score was indicative of more positive expectations about the hearing aid(s).
- The Participation Restriction score was computed as the sum of responses to the items of the HHIE. The range of possible scores was 0 to 100. Higher scores were indicative of more problems with participation restrictions in daily life.

TABLE 4. Linear correlation coefficients among five personality traits, Response Bias, and the other prefitting self-report variables

	Neuroticism	Extraversion	Openness	Agreeable-ness	Conscientious-ness	Responsebias
Response bias	**−0.35**	0.13	0.00	**0.45**	**0.32**	
Expectations (ECHO)	**−0.20**	0.18	−0.04	**0.21**	**0.27**	
Participation restriction (unaided HHIE)	**0.46**	**−0.27**	−0.13	**−0.29**	−0.13	**−0.26**
Activity limitation (unaided APHAB Global)	**0.33**	**−0.24**	**−0.21**	−0.14	−0.10	**−0.19**
Sound aversiveness (unaided APHAB AV)	**0.38**	**−0.23**	**−0.21**	**−0.29**	−0.11	−0.16
Degree-unaided-difficulty	−0.03	0.05	−0.02	0.02	0.01	−0.05

Statistically significant values ($p \leq 0.01$, two-way) are shown in bold font.

- The Activity Limitation score was computed as the average of scores for the EC, RV, and BN subscales of the APHAB. The possible range for the scores was 1 to 99. Higher scores were indicative of more frequent problems with speech communication performance (activity limitations) in daily life.
- The Sound Aversiveness score was the AV subscale score of the APHAB. The possible range was 1 to 99. Higher scores were indicative of more frequent problems with aversiveness of sounds in daily life.
- The Degree-unaided-difficulty score was determined as: none = 0, mild = 1, moderate = 2, moderately-severe = 3, and severe = 4.

Associations Among Personality, Response Bias, and Traditional Prefitting Variables

Table 4 shows the linear correlation coefficients between personality traits, Response Bias, and the traditional prefitting variables. Statistically significant ($p \leq 0.01$) values are in bold type.

Sound Aversiveness revealed a significant association with four of the five personality traits. Individuals who were higher in Extraversion, Openness, and Agreeableness were less likely to report that environmental sounds were unpleasant, whereas individuals who were higher in Neuroticism were more likely to have a negative reaction to environmental sounds. This comprehensive association between personality and sound aversion is especially interesting because problems with unpleasant or uncomfortable sounds is one of the most frequent precipitators of unsuccessful hearing aid fittings (Kochkin, 2000).

Reports of Activity Limitations (APHAB) were similar to Participation Restrictions (HHIE) in that higher Neuroticism and lower Extraversion were associated with more reported problems in daily life. In addition, Activity Limitations and Participation Restrictions were both significantly related to Response Bias: A tendency (bias) to portray oneself more positively was associated with reporting fewer hearing problems on the APHAB and the HHIE.

Response bias also was related to three personality traits (Neuroticism, Agreeableness, and Conscientiousness). Individuals who were higher in Agreeableness and Conscientiousness and lower in Neuroticism were more likely to give responses to self-report queries that portrayed the individuals positively. Hearing aid expectations reported on the ECHO showed a pattern of relationships with personality that were rather parallel to those of Response Bias. Individuals who were higher in Agreeableness and Conscientiousness and lower in Neuroticism were more likely to report high expectations for their hearing aids.

In summary, Response Bias was moderately related to personality traits, with the closest association occurring with Agreeableness. Further, each of the personality traits, and Response Bias, was significantly associated with at least two of the traditional prefitting variables, but the pattern of associations was different for different variables. The personality trait most frequency associated with traditional prefitting variables was Neuroticism, although Agreeableness and Extraversion were also conspicuously represented. Finally, it was of interest to note that the Degree-Unaided-Difficulty variable was not significantly associated with personality or Response Bias.

Contributions of Hearing Loss to Traditional Prefitting Variables

When practitioners ask patients about their everyday hearing problems, it is tacitly assumed that the answers depend to a large extent on the patient's hearing loss as reflected in the audiogram. It was of interest to explore this assumption by evaluating the extent to which variation in personality and response bias might also make contributions to daily life hearing problems that individuals report. This was addressed using stepwise regression analyses in which personality traits, Response Bias, and audiogram-based hearing loss were used as potential predictors of expectations and the measures of hearing disablement. The variable reflecting audiometric hearing loss in this and later analyses was the four

TABLE 5. Variance in hearing-specific self-report variables that can be attributed to variations in audiometric hearing loss (4FAHL), personality, and response bias (smallest N = 203)

Hearing-specific variable	Predictor variable(s)	Variance explained (%)	Direction of relationship
Expectations (ECHO)	Conscientiousness	7	+
Participation restriction (unaided HHIE)	Neuroticism	21	+
	4FAHL	5	+
Activity limitation (unaided APHAB Global)	Neuroticism	11	+
	4FAHL	8	+
	Openness	1	−
Sound aversiveness (unaided APHAB AV)	Neuroticism	14	+
Degree unaided difficulty	4FAHL	10	+

frequency average hearing loss (4FAHL), defined as the average threshold for 500, 1000, 2000, and 4000 Hz (left and right ear combined). The regression results, shown in Table 5, support the following statements:

- Most of the hearing-specific self-report variables were more strongly associated with personality than with the audiogram.
- The prefitting variable most predictable from personality was Participation Restriction measured using the HHIE. The Neuroticism trait accounted for 21% of the variance in HHIE scores with higher neuroticism being predictive of greater reported hearing disablement. Although Extraversion and Agreeableness both also were significantly correlated with HHIE scores (Table 4), neither of them made an additional contribution to prediction of HHIE score once Neuroticism was taken into account. Hearing loss made a significant but much smaller contribution to this variable, accounting for only 5%.
- The trait of Neuroticism also was implicated in the Activity Limitation score derived from the APHAB, accounting for 11% of the variance, with higher Neuroticism predictive of more reported hearing disablement. Although hearing loss contributed to the Activity Limitation score, the contribution (8% of the variance) was less than that of Neuroticism. Openness also contributed very slightly to the variance in Activity Limitation.
- The trait of Neuroticism accounted for 14% of the variance in Aversiveness of environmental sounds. Despite the multiple associations shown in Table 4, no other personality trait made a significant additional contribution to prediction of Aversiveness once Neuroticism was accounted for. Hearing loss did not make a significant contribution to the Aversiveness score.
- The Expectations score was associated to some extent with the personality trait of Conscientiousness, but Expectations was not at all associated with hearing loss. Because Conscientiousness accounted for 7% of the Expectations score, it can be speculated that subjects who know themselves to be prepared to work for success with amplification might have higher pre-fitting expectations. Except for this relatively small contribution, personality was not associated with hearing aid expectations as quantified by the ECHO.
- Response Bias did not make an independent contribution to any of the traditional self-report variables.

Overall, it was determined that the personality make-up of hearing aid candidates was clearly predictive of their reported extent of hearing difficulties in daily life, whereas severity of hearing loss was a conspicuously less effective predictor. The trait of Neuroticism was most strongly related to subjective reports about unaided listening concerns.

Hearing Aid Fitting Variables

Each hearing aid fitting was documented in terms of three variables that are widely used as indicators of fitting quality: soft sound audibility, match to target gain for conversational speech, and appropriateness of maximum output. The distribution of these variables is shown in Figure 2, Figure 3, and Figure 4, respectively.

Figure 2 reveals that when subjects were aided, low-frequency soft sounds were generally audible at lower levels than high-frequency soft sounds. This is a typical finding for individuals with sloping audio-

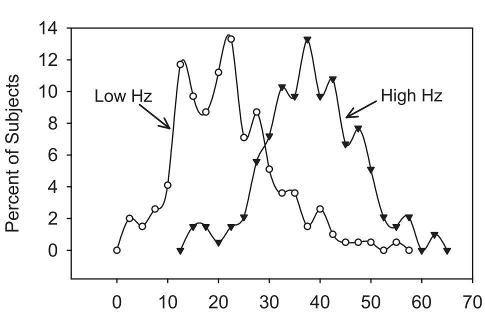

Fig. 2. Distribution of aided sound field thresholds for warble tones. Low-frequency audibility was represented as the average of thresholds at 250 Hz and 500 Hz (N = 196). High-frequency audibility was represented as the average of thresholds at 2000 Hz and 4000 Hz (N = 195).

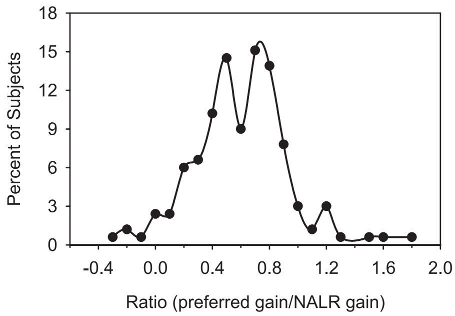

Fig. 3. Distribution of gain for conversational speech, assessed as the ratio of average preferred coupler gain to average coupler gain prescribed using the NAL-R prescription procedure. Test frequencies were 1000, 2000, and 4000 Hz, input was 65 dB SPL.

metric configuration, since effective amplification is technically easier to accomplish for low-frequency sounds than for high-frequency sounds. For a typical subject, the softest detectable sounds were around 20 dB HL for low frequencies and around 35 dB HL for high frequencies. These values are a good match to recommended optimal aided thresholds (e.g., Killion, 1996).

Figure 3 illustrates the gain (left and right ear average) preferred by subjects in the clinic on the day the hearing aid was fitted. To provide a context for these data that is not dependent on hearing loss, the chosen gain is expressed as a proportion of the gain prescribed for that patient using the NAL-R prescriptive formula. Thus, a gain ratio near 1.0 indicates that the patient preferred gain similar to the prescribed amount for their hearing loss. More than 1.0 denotes selection of more gain than prescribed. Less than 1.0 denotes selection of less gain than prescribed. Note that most subjects preferred a listening level that provided gain of half to three-quarters of the prescribed value for their hearing loss. A few even set the hearing aids to produce negative gain, which indicates that they were allowing normal unamplified sound to arrive via the earmold vent (if present) but no additional sound from the new hearing aids. It should be remembered that subjects were not obliged to continue using the amount of gain chosen at this clinic appointment. Many of them had manual volume controls and all were seen for follow-up visits when gain could be increased. However, previous studies have reported that patients often choose to use less gain than that prescribed by the NAL-R formula (e.g., Humes et al., 2000; Smeds, 2004; Smeds, Keidser, Zakis, et al., 2006).

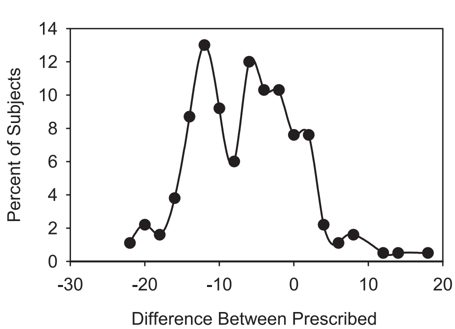

Fig. 4. Distribution of maximum output values in fitted hearing aids. This was assessed by computing the difference between the optimum high-frequency average (HFA) OSPL90 prescribed using the NAL procedure and the fitted HFA OSPL90 measured in a 2-cc coupler.

Figure 4 illustrates the HFA OSPL90 (left and right ear average) for the fitted hearing aids relative to the "optimal" HFA OSPL90 prescribed by the NAL procedure (Dillon & Storey, 1998). A positive value indicates that the fitted maximum output was higher than the prescribed optimal number and a negative value depicts a fitting in which the maximum output was lower than the prescribed optimal number. Note that in most of the fittings the maximum output was lower than prescribed by the NAL method.

Correlations were computed between the four hearing aid fitting variables and the patient-based variables that were of interest in this study. These included: personality traits derived from the NEO-FFI questionnaire (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness), Response Bias, audiogram hearing loss (4FAHL), previous hearing aid experience, type of service provision (public health VA or not), expectations, extent of Degree-Unaided-Difficulty, unaided participation restrictions (HHIE), unaided activity limitations (APHAB global communication problems), and aversiveness of unamplified sounds (APHAB AV). There were only four statistically significant ($p \leq 0.01$) correlations: Individuals with more hearing loss (4FAHL) produced higher (poorer) aided sound field thresholds in both low frequencies ($r = 0.47$) and high frequencies ($r = 0.36$); VA patients tended to have lower (better) aided low-frequency sound field thresholds than non-VA patients ($r = 0.23$)*; and patients with higher scores for Response Bias tended to have lower (better) aided high-frequency sound field thresholds ($r = -0.24$).

Six-Month Post-fitting Outcomes

Scoring

- Aided functioning was measured with the HHIE and APHAB questionnaires, and scoring for each questionnaire was the same as described above for unaided functioning. This yielded scores in the

*See Cox et al (2005a) for a discussion of the basis of this association.

TABLE 6. Mean, standard deviation, and number of subjects for each of the outcome variables

Outcome domain	Variable	Mean	Standard deviation	Subjects (n)
Residual disablement	Participation restriction (aided HHIE)	18.7	18.3	205
	Activity limitation (aided APHAB global)	28.4	15.4	203
	Sound aversiveness (aided APHAB AV)	43.9	24.6	203
Benefit	Difference HHIE	27.7	19.9	205
	Difference APHAB global	28.7	19.3	203
	SHAPIE	3.92	0.49	202
Satisfaction	SADL PE	5.04	1.05	205
	SADL SC	5.61	1.04	202
	SADL NF	5.05	1.18	199
	SADL PI	5.96	0.89	205
	Overall satisfaction	4.12	0.80	204
Use	Daily use	7.9	3.9	205

range of 0 to 100 for aided Participation Restrictions, and 1 to 99 for aided Activity Limitations and Aversiveness of amplified sounds.

- Difference benefit was computed for Participation Restrictions (HHIE Total score) by subtracting aided problems from unaided problems. The same method was used to compute difference benefit for Activity Limitations using the APHAB global score data.
- Direct benefit was computed as the average of responses to all 25 items of the SHAPIE questionnaire. The responses were scored as follows: very helpful = 5, helpful = 4, very little help = 3, no help = 2, hinders performance = 1. Thus, the scores ranged from 1 to 5, with a higher score indicative of more benefit.
- Overall satisfaction was measured using the single item query described above. Responses were scored on a five-point scale as follows: very dissatisfied = 1, dissatisfied = 2, neutral = 3, satisfied = 4, and very satisfied = 5.
- Four satisfaction subscale scores were computed from responses to the SADL questionnaire. Each subscale score is the average response for the subscale items. Each item response is scored from 1 to 7 with higher scores indicating greater satisfaction. Thus, each subscale score ranged from 1 to 7. The Positive Effect (PE) subscale quantifies improved psychoacoustic and psychological functioning. The Service and Cost (SC) subscale quantifies dispenser competence and hearing aid value. The Negative Features (NF) subscale quantifies the impact of potentially unpleasant side effects of using amplification. The Personal Image (PI) subscale quantifies the hearing-impaired listener's view of himself/herself as a hearing aid wearer.
- To quantify typical daily hearing aid use, each use category was scored according to the midpoint of its range, as follows: none = 0, less than 1 hour = 0.5, 1 to 4 hours = 2.5, 4 to 8 hours = 6, 8 to 16 hours = 12.

Table 6 gives descriptive statistics for the outcome variables. Table 7 shows the correlations among the outcome variables. Note that many of the outcome variables are significantly correlated, which indicates that they are measuring related constructs. However, the correlation coefficients point to weak to moderate strength associations, which is consistent with the view that the diverse measures capture somewhat different aspects of the consequences of amplification in daily life.

Associations Among Personality, Response Bias, and Self-Report Data in Different Outcome Domains

Table 8 depicts the correlation coefficients showing the strength of relationships between the five

TABLE 7. Linear correlation coefficients among outcome variables

	A-HHIE	A-GBL	A-AV	R-HHIE	R-GBL	SHAPIE	USE	SADL-PE	SADL-SC	SADL-NF	SADL-PI	OASAT
A-HHIE	1	**0.63**	0.18	**−0.28**	**−0.24**	**−0.44**	0.01	**−0.27**	**−0.24**	**−0.36**	**−0.38**	**−0.33**
A-GBL		1	**0.23**	**−0.26**	**−0.50**	**−0.58**	−0.06	**−0.46**	**−0.44**	**−0.38**	**−0.31**	**−0.40**
A-AV			1	0.09	0.05	−0.16	−0.13	−0.04	−0.05	−0.17	−0.17	−0.11
R-HHIE				1	**0.58**	0.16	0.16	**0.33**	**0.22**	**0.21**	0.10	**0.20**
R-GBL					1	**0.33**	**0.25**	**0.48**	**0.32**	**0.23**	**0.24**	**0.23**
SHAPIE						1		**0.50**	**0.44**	**0.32**	**0.32**	**0.39**
USE							1	**0.37**	0.15	−0.02	**0.23**	0.17
SADL-PE								1	**0.49**	**0.29**	**0.22**	**0.58**
SADL-SC									1	0.18	**0.22**	**0.48**
SADL-NF										1	**0.26**	**0.39**
SADL-PI											1	**0.21**

Statistically significant values (p ≤ 0.01, two-way) are shown in bold font.
A-HHIE = aided HHIE; A-GBL = aided APHAB global; A-AV = aided APHAB AV; R-HHIE = difference HHIE benefit; R-GBL = difference APHAB benefit; SHAPIE = direct SHAPIE benefit; USE = hours of daily use; SADL-PE = SADL PE subscale; SADL-SC = SADL SC subscale; SADL-NF = SADL NF subscale; SADL-PI = SADL PI subscale; OASAT = overall satisfaction (smallest N = 202).

TABLE 8. Linear correlation coefficients between outcome variables and personality traits (N, E, O, A, C) and response bias (B)

Outcome domain	Variable	N	E	O	A	C	B
Residual disablement	Participation restriction (aided HHIE)	**0.38**	**−0.24**	−0.10	**−0.28**	−0.18	**−0.30**
	Activity limitation (aided APHAB global)	**0.31**	**−0.19**	−0.18	−0.15	**−0.21**	−0.14
	Sound aversiveness(aided APHAB AV)	**0.22**	**−0.19**	−0.12	−0.15	−0.07	−0.11
Benefit	Difference HHIE	**0.18**	−0.11	−0.08	−0.08	−0.01	0.01
	Difference APHAB	0.04	−0.07	−0.04	−0.02	0.07	−0.05
	SHAPIE	**−0.18**	0.08	0.13	0.13	0.14	0.08
Use	Daily Use	−0.07	0.08	0.03	0.12	0.10	0.07
Satisfaction	SADL PE	−0.06	0.13	0.1	0.05	0.17	−0.11
	SADL SC	−0.14	0.14	0.00	0.09	**0.19**	0.06
	SADL NF	0.02	0.03	−0.08	0.00	0.05	−0.00
	SADL PI	**−0.32**	**0.26**	0.06	**0.31**	**0.22**	**0.16**
	Overall satisfaction	−0.12	0.12	0.14	0.12	0.13	0.04

Statistically significant values ($p \leq 0.01$, two-way) are shown in bold font (smallest $N = 199$).

personality traits and each outcome variable. In addition, the Table shows the relationship between Response Bias and outcomes. These results support the following statements:

- Measures of residual disablement (problems remaining even when amplification is used) showed a pattern of associations with personality rather similar to those shown in Table 4 for disablement without amplification. Both Neuroticism and Extraversion were significantly related to all three measures of residual disablement. The strength of relationship between self-report and personality was generally somewhat less for aided listening than for unaided listening. For example, the correlation coefficient between Neuroticism and Participation Restrictions was 0.46 in Table 4 (unaided) but reduced to 0.38 in Table 8 (aided). A tendency towards socially correct responding (Response Bias) was found to be associated with reports of fewer aided problems with participation restrictions.
- Measures of benefit revealed only two significant relationships with personality and these were not strong. Plausibly, SHAPIE direct benefit was negatively related to Neuroticism, that is, higher Neuroticism was associated with lower reported benefit. On the other hand, HHIE difference benefit was positively related to Neuroticism. This curious result indicates that higher neuroticism was associated with greater reported benefit when the benefit domain was examined using the difference method and the HHIE questionnaire. To explore this counter-intuitive relationship, the one-third of subjects with highest N scores was compared with the one-third of subjects with lowest N scores. The result, which is shown in Figure 5, exposed a potential difficulty with quantifying outcome using difference benefit. As the figure illustrates, individuals with higher Neuroticism reported more problems than individuals with lower Neuroticism for both unaided and aided listening. This is what would be predicted based on the characteristics of the Neuroticism trait. However, when the difference between aided and unaided problems was computed to produce difference benefit, the benefit was greater for listeners with higher Neuroticism scores. Although this result is accurate, it could be misleading if interpreted outside the context of aided and unaided scores.
- The measure of Use was not significantly related to any personality trait. Further, it was encouraging to note that reported daily use was not found to be related to Response Bias. In other words, there was no evidence that individuals who tend to portray themselves in a positive way were more inclined to report greater use of amplification.
- Of the five measures of Satisfaction, the Personal Image (PI) subscale of the SADL was found to be related to four of the five personality traits, as well as to response bias. This subscale encompasses sensitive issues touching on the hearing-impaired

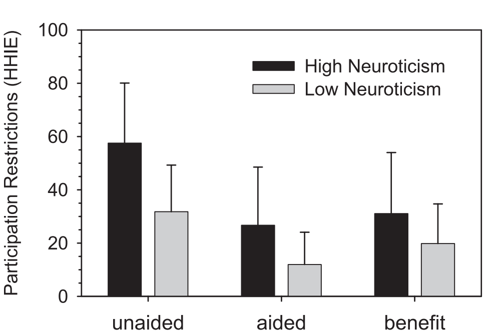

Fig. 5. Mean scores for the HHIE questionnaire in unaided and aided listening and difference benefit computed from these data. The one third of subjects with highest Neuroticism scores is shown compared with the one third of subjects with lowest Neuroticism scores. Bars depict 1 standard deviation.

listener's self-image and the way he or she believes that they are perceived by others, so the relationship with personality variables is not surprising. With the exception of a weak relationship between the Service and Cost score and Conscientiousness, there were no other significant relationships between personality and satisfaction measures.

Overall, these results suggest that questionnaires probing problems that the hearing aid wearer continues to have after obtaining amplification (residual disablement) elicit responses that are somewhat related to personality. By comparison, questionnaires in the benefit, use and satisfaction domains generally produce responses that are less related to personality (but note the exception for the SADL PI subscale). Also, when benefit is measured using unaided/aided differences, it is possible to obtain counter-intuitive relationships with personality which could be misleading if interpreted in isolation (as with the HHIE questionnaire). Finally, a tendency toward socially correct responding was not found to be an important influence in most of these hearing aid outcome measures.

Seeking the "Big Picture" in Self-Report Outcomes

One of the central concerns of this investigation was to evaluate the contributions of patient-based and hearing aid-based variables to the subjective outcomes of hearing aid provision. A challenge that must be met in accomplishing that goal is to determine what will constitute the outcome data that we attempt to explain or predict. In this investigation, self-report outcomes were quantified in a dozen different ways. As shown in Table 7, the data yielded by different outcome questionnaires are usually not closely related. Thus, a patient who scores highly on one outcome measure might not score highly on a different measure, even when the measurements are made within the same outcome domain. To illustrate, Table 7 gives inter-correlations among three measures of benefit (difference benefit from APHAB and HHIE, and direct benefit from SHAPIE). The strongest association is $r = 0.58$ between the HHIE benefit and APHAB benefit, which indicates a moderate overlap between these two measures. On the other hand, the correlation between the SHAPIE and APHAB benefit was $r = 0.33$ and that between SHAPIE and HHIE benefit was $r = 0.16$. Clearly, these correlations show that self-report benefit measured in different ways can produce quite different results, and an individual who reports large benefit on one measure might not report large benefit on a different measure.

Notwithstanding this daunting result, all of the approaches to self-report outcome measurement used in this study are widely used in practice and research, and each one is arguably valid. So it is not a straightforward matter to select a single measure that can encapsulate the entire self-report outcome universe. Other researchers have grappled with this dilemma, especially in attempting to elucidate the relationship between laboratory outcomes such as recognition of amplified speech and self-report outcomes such as benefit and satisfaction (e.g., Gatehouse, 1994; Humes, 1999).

Derivation of Outcome Components

In the present study, the problem of determining the outcome metric was addressed by subjecting the set of outcome data to a principal components analysis in an attempt to glean an underlying structure within the self-report data from different questionnaires. All of the variables listed in Table 7 were entered into this analysis except difference benefit determined from HHIE and APHAB data. These were omitted on the grounds that they were derived from the aided HHIE and APHAB data (and were therefore not independent measures) and also because of the anomalous relationship between personality and difference HHIE benefit (Table 8). Only subjects with no missing data were used in the analysis ($N = 191$).

To improve the interpretability of the derived components, all of the outcomes were scaled such that a higher score corresponded to a better result. This involved converting HHIE and APHAB data from frequency-of-problems to frequency-of-success (e.g., a frequency of problems = 40% was converted into a frequency of success = 60%).

The principal components analysis was performed using SPSS version 12. Criterion for retaining a component was specified as eigenvalue $\geq$1.0. Three components were identified, together accounting for 61.4% of the variance of the 10 self-report outcome measures. Orthogonal (varimax) rotation was used to derive more interpretable loadings. The resulting variable loadings are summarized in Table 9. The Table also gives the communality of each outcome variable, which shows the proportion of the variable's variance that is accounted for by the combination of the three components. The communalities indicate that most of the outcome variables are rather well accounted for in the 3-component solution. The SADL NF and PI subscales have the lowest communalities, with values of 0.41 and 0.45, respectively.

Most of the outcome variables made substantial contributions to only one component, but SHAPIE benefit and daily Use each contributed to two com-

TABLE 9. Loadings of each outcome measure on each of three principal components after orthogonal rotation

Outcome variable	Communality	Device component (37.8%)	Success component (12.7%)	Acceptance component (10.9%)
Aided HHIE (reversed)	0.66		0.796	
Aided APHAB global (reversed)	0.69		0.718	
Aided APHAB aversiveness (reversed)	0.57			0.693
SHAPIE benefit	0.60	0.521	0.554	
Use	0.80	0.457		0.698
SADL (PE)	0.76	0.842		
SADL (SC)	0.60	0.740		
SADL (NF)	0.41		0.613	
SADL (PI)	0.45			0.519
Overall satisfaction	0.59	0.722		

Only loadings higher than .45 are shown. The percent of variance in outcome data that is accounted for by each component is specified. Communality of each variable is also given. (N = 191).

ponents. This sharing of variables prompted an exploration of the use of an oblique rotation (Promax with Kaiser normalization, k = 4) of the derived components to assess the potential relationship among them. The result indicated that the correlation between the first and second components was $r = 0.31$ and that between the first and third components was $r = 0.36$. There was a minimal relationship between the second and third components ($r = -0.11$). Overall these relatively weak associations indicated that the three outcome components could reasonably be modeled as independent of each other.

Each of the components was readily interpretable. The first component, which accounted for 37.8% of the outcome variance, was labeled the Device component based on the item content of the highest loading variables. The SADL PE and SC subscales address the excellence or merit of the hearing aid, as does the overall satisfaction score. Smaller contributions were made to this component by SHAPIE benefit and daily Use. The second component, which accounted for 12.7% of the outcome variance, was labeled the Success component because it is dominated by the wearer's frequency of success when wearing hearing aids in daily life situations that may be affected by hearing loss (HHIE and APHAB), as well as success with potentially negative aspects of hearing aids (SADL NF). SHAPIE benefit also contributed to this component to a lesser degree. The third component, which accounted for 10.9% of the outcome variance, was labeled the Acceptance component because it comprised three elements that all must be present before the device can be considered accepted by the wearer at a psychological level: daily use, tolerable environmental sounds (APHAB AV), and comfortable self image (SADL PI). The Device component focuses more on the hearing aid whereas the Success and Acceptance Components focus more on the wearer.

Based on these results, it seemed plausible to view self-report outcomes of hearing aid provision as comprising elements of device merit, success in daily life, and amplification acceptance. For use in the subsequent analyses, three standardized component scores were derived for each subject using the factor score coefficients produced by the principal components analysis.

Exploring Precursors of Outcome Component Scores

In this report, we are focusing on three types of precursor variables that have, on logical grounds, potential as determinants or predictors of self-report outcomes of hearing aid provision. The variables are:

Type 1: Personality traits derived from the NEO-FFI questionnaire (Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness), and Response Bias.

Type 2: Traditional hearing-specific variables that are widely measured and are available before the hearing aid fitting. They include audiogram data, previous hearing aid experience, type of service provision (public health VA or not), expectations, extent of Degree-Unaided-Difficulty, unaided participation restrictions (HHIE), unaided activity limitations (APHAB global communication problems), and aversiveness of unamplified sounds (APHAB AV).

Type 3: Four widely used hearing aid fitting verification variables: low-frequency soft sound audibility, high-frequency soft sound audibility, ratio of preferred to prescribed gain at fitting, and difference between fitted and prescribed maximum output.

Precursor Type 1: Personality and Response Bias • The extent to which differences in personality or response bias might underlie differences in the three outcome component variables was examined. For five traits and Bias, the subject group was

TABLE 10. Results of multivariate analyses of variance exploring post-fitting differences in each component of self-report outcome for subjects with higher or lower scores on five personality traits and Response Bias

Precursor variable	*N*	Device component	Success component	Acceptance component
Neuroticism	127	NS	Low > High	Low > High
Extraversion	123	NS	High > Low	NS
Openness	130	NS	NS	NS
Agreeableness	116	NS	High > Low	High > Low
Conscientious-ness	125	NS	NS	NS
Response bias	107	NS	High > Low	High > Low

When outcome differences were significant, the direction of the difference is indicated in the Table (e.g., subjects with low Neuroticism reported better scores on the Success component than subjects with high Neuroticism). NS = not significant (p > 0.05).

partitioned into three approximately equal segments based on the distribution of scores from high to low. Subjects with middle-range scores on the variable were not used in the analysis. Multivariate analyses of variance was performed to determine whether scoring higher or lower on a variable was significantly associated with higher or lower outcomes in the Device, Success, or Acceptance components. A separate analysis was performed for each of the six precursor variables. The results are summarized in Table 10.

As the Table shows, neither personality trait scores nor Response Bias were associated with significant differences in the Device component of outcome. However, three personality traits and Response Bias were associated with significant differences in the Success component of outcome. Subjects with lower Neuroticism ($F(1,125) = 12.88$, $p < 0.001$), higher Extraversion ($F(1,121) = 9.96$, $p = 0.002$), higher Agreeableness ($F(1,114) = 7.69$, $p = 0.006$), or higher Response Bias ($F(1,105) = 7.88$, $p = 0.005$) yielded higher outcomes on the Success component. Finally, two personality traits and Response Bias were associated with significant differences in the Acceptance component of outcome. Subjects with lower Neuroticism ($F(1,125) = 6.87$, $p = 0.01$), higher Agreeableness ($F(1,114) = 8.18$, $p = 0.005$), or higher Response Bias ($F(1,105) = 4.34$, $p = 0.04$) yielded higher outcomes on the Acceptance component.

In summary, personality was not found to be associated with the aspect of self-report outcome that is more focused on the hearing aid device itself (the Device component). However, when the self-report items involved focusing the wearer's attention inwardly on his/her problems, limitations, etc., (the Success and Acceptance components) aspects of personality, especially Neuroticism and Agreeableness, were found to be associated with the hearing aid outcome scores. Response Bias was also found to be associated with the Success and Acceptance components of outcome and basically paralleled the results for the Agreeableness trait. This is consistent with the relationship between Agreeableness and Response Bias noted in Table 4.

Precursors Types 2 and 3: Traditional Prefitting and Fitting Verification Variables • Each of the traditional prefitting and verification variables listed above was examined to determine whether differences in prefitting variables were associated with differences in each of the three components of outcomes. Continuously distributed variables were categorized into high, medium, and low scores, and the analyses were carried out using only the high- and low-scoring subgroups (omitting the middle-scoring subjects). Multivariate analysis of variance, analogous to that used for the personality variables was used for these analyses. The results are summarized in Table 11.

As seen in Table 11, only three variables were associated with the Device component of outcome. The hearing aid was rated more positively by patients who reported more Degree-Unaided-Difficulty, were seen in a VA Audiology service, or had higher prefitting expectations. This aspect of fitting outcome was not associated with hearing loss, previous experience, the problems questionnaires (HHIE and APHAB), or the fitting verification data.

On the other hand, all but two of the precursor variables were significantly associated with the Success component of outcome. Subjects with high scores on this component generally had less hearing loss both objectively (audiogram) and subjectively (degree-unaided-difficulty), higher prefitting expectations, fewer unaided problems in the HHIE and APHAB questionnaires, and were new users of amplification. In addition, a higher score on the Success component was reported by patients who achieved better (lower) aided sound field thresholds in the low-frequency region. Also, those who preferred lower gain settings at the fitting, or were fitted with lower MPO, relative to the prescribed value for their hearing loss, subsequently reported higher Success scores.

In contrast to the many associations with the Success component, the other wearer-oriented component—the Acceptance Component—was significantly associated with only two of the precursor variables. Greater acceptance of the hearing aid was found for individuals who reported higher Degree-Unaided-Difficulty and less Aversiveness to unamplified environmental sounds.

In summary, the Success component of self-report outcome was significantly associated with most of the traditional prefitting and fitting verification variables considered in this study and frequently obtained in the hearing aid fitting process. However,

TABLE 11. Results of multivariate analyses of variance exploring post-fitting differences in each component of self-report outcome for subjects with higher or lower scores on prefitting and fitting verification variables

Precursor variable	N	Device component	Success component	Acceptance component
Audiogram hearing loss (4FAHL)	125	NS	Low > High $p = 0.001$	NS
Degree unaided-difficulty (mild = 1, moderate = 2, mod-severe = 3, severe = 4	189	1 < 2 < (3 & 4) $p < 0.001$	(1 & 2) > (3 & 4) $p = 0.004$	(1 & 2) < (3 & 4) $p = 0.015$
Previous HA experience	191	NS	No > Yes $p < 0.001$	NS
Type of service	191	VA > nonVA $p = 0.004$	NS	NS
Expectations (ECHO)	126	High > Low $p < 0.001$	High > Low $p = 0.022$	NS
Participation restrictions (unaided HHIE)	132	NS	Low > High $p < 0.001$	NS
Activity limitations (unaided global APHAB)	125	NS	Low > High $p < 0.001$	NS
Sound aversiveness (unaided APHAB AV)	129	NS	Low > High $p = 0.019$	Low > High $p < 0.001$
Aided low-frequency thresholds	130	NS	Lower > Higher $p < 0.001$	NS
Aided high-frequency thresholds	132	NS	NS	NS
Preferred gain relative to prescribed gain	115	NS	Less > More $p = 0.047$	NS NS
Fitted MPO relative to prescribed optimal MPO	122	NS	Lower > Higher $p = 0.045$	NS

When outcome differences were significant, the direction of the difference is indicated in the table (e.g., subjects with low 4FAHL reported better scores on the Success component than subjects with high 4FAHL). NS = not significant (p > 0.05). Probability values are for the multivariate between-subjects effect.

the Device and Acceptance outcome components were associated with only three and two prefitting variables, respectively, and were not associated with any of the variables traditionally used in fitting verification.

Prediction of Self-Report Outcome

A central interest in this study was to evaluate the relative contributions of the patient variables (personality and prefitting measures) and the hearing aid variables (verification measures) to the self-report outcomes of the fitting. The goal was to determine the extent to which variations in patient variables and in hearing aid variables accounted for variations in the outcome components. As shown in Tables 10 and 11, personality, traditional prefitting, and fitting verification variables are all associated with some aspect of self-report hearing aid fitting outcomes. It should be noted, however, that some of these variables are also associated with each other (e.g., Table 4 illustrates that many of the traditional prefitting variables are significantly associated with personality traits). Thus, further analyses are needed to determine which variables make the major independent contributions to the self-report fitting outcome.

This matter was examined by performing stepwise multiple regression analyses in which the potential predictor variables functioned as the independent variables and one of the outcome components became the dependent variable. Thus, there were three regression analyses. The results are depicted in Table 12. The first regression analysis indicated that prefitting expectations was the strongest predictor of the Device component of outcome with Degree-Unaided-Difficulty and service type (VA or PP) also making significant independent contributions to prediction. Twenty-seven percent of the total variance in Device outcome was accounted for by these three variables. It is noteworthy that none of the variables derived from the hearing aid fitting verification contributed additional independent information to prediction of the Device outcome, and that the personality variables did not add any explanatory power.

The second regression analysis indicated that the predictor variables accounted for 43% of the variance in the Success component of outcome, with the largest contribution made by unaided problems reported on the HHIE. Previous hearing aid experience and sound aversiveness were patient variables that made additional contributions to this outcome component. In addition, two of the hearing aid fitting verification variables—low-frequency aided audibility, and hearing aid gain relative to prescription—also made significant independent contribu-

TABLE 12. Results of stepwise regression analyses determining the extent to which the variance in each outcome component was attributable to the full set of potential predictor variables (hearing specific prefitting, verification measures, and personality)

Potential predictor variable	Regression step and percent of variance: Device component	Success component	Acceptance component
Audiogram hearing loss (4FAHL)			
Degree-unaided difficulty	Step 2 7%		Step 2 5%
Previous HA experience		Step 2 10%	
Type of service	Step 3 5%		
Expectations (ECHO)	Step 1 15%		
Participation restrictions (unaided HHIE)		Step 1 19%	
Activity limitations (unaided global APHAB)			
Aversiveness (unaided APHAB AV)		Step 4 4%	Step 1 15%
Aided low-frequency thresholds		Step 3 8%	
Aided high-frequency thresholds			
Preferred gain relative to prescribed gain		Step 5 2%	
Fitted MPO relative to prescribed optimal MPO			
Response bias			
Neuroticism			
Extraversion			
Openness			
Agreeableness			
Conscientiousness			
Total % of variance	27%	43%	20%

Significance of $p < 0.05$ was required for entry into the table. Entries show the regression step at which the variable was entered and the percent of variance (r^2) of the outcome component score that was accounted for by the variable. For each component, the total percent of variance accounted for by all entered variables is also given. ($N = 150$).

tions. As seen for the Device outcome component, the personality variables did not add any independent information to the prediction of the Success outcome component.

The third regression analysis revealed that only two variables made independent contributions to the prediction of the Acceptance component of outcome. Sound Aversiveness and Degree-Unaided-Difficulty together accounted for 20% of the outcome variance. Neither the hearing aid fitting verification variables nor the personality variables provided additional independent input to the prediction of the this component.

In summary, patient-based variables accounted for 20 to 33% of the variance in all three outcome components, although for the most part, each outcome component was associated with different constellation of patient-based variables. The most powerful patient-based predictors of outcome were conventional, hearing-related self-report variables. The personality variables did not figure independently in the regression equations. Finally, variables traditionally used to verify the quality of fitted hearing aids made an independent contribution to only one of the outcome components (Success), and the verification details accounted for a total of only 10% of the variance in self-report fitting outcome.

DISCUSSION

This investigation was designed to clarify the extent to which patient differences and amplification differences contribute to differences in self-report outcome data that quantify the real world effectiveness of hearing aids. It was postulated that a combination of patient variables (personality and hearing-related subjective variables that are often obtained in current practice before a hearing aid fitting) and amplification variables (audibility, gain, and maximum output), would be found to explain a substantial percentage of the variance in self-report outcomes of the fitting. An additional goal was to determine whether any of the questionnaires used to assess self-report outcome measurement is less susceptible than other approaches to personality effects.

Components of Self-Report Outcome

An important result of this investigation was the derivation of three components of self-report outcomes that are plausible and interpretable as generic indicators of the daily life consequences of amplification. The outcome components were derived from a collection of ten widely used scales and subscales, and each component comprises contributions from several questionnaires. Thus, the set of three components yields insight into the building blocks of hearing aid outcomes that transcends the specific questionnaires used in current practice and research. The three components together accounted for 61.4% of the variance in outcomes. One component (labeled "Device"), which accounted for about 38% of the variance in outcomes, seemed to be associated with the excellence of the hearing aid per se (e.g., is it worth the trouble and cost, is it helpful?). The two other components (labeled "Success" and "Acceptance"), which accounted for about 24% of the variance in outcomes, seemed to be associated with the hearing aid wearer him/herself (e.g., are you free of frustration and annoyance, do you continue to have problems in noise?). Thus, it is reasonable to view these components as device-based outcomes and wearer-based outcomes.

Personality Effects

It was determined that self-report data that are commonly obtained before a hearing aid fitting are often significantly associated with one or more of the five personality traits quantified by the NEO-FFI questionnaire. As shown in Table 4, this included data from the HHIE and APHAB questionnaires to document the patient's real life hearing problems, as well as expectations data from the ECHO questionnaire. In fact, as shown in Table 5, reports of hearing problems and hearing aid expectations tend to be more strongly related to the patient's personality than to his/her hearing impairment. These kinds of results have been reported by other investigators, and so they are not unexpected (see, for example, Gatehouse, 1990; Saunders & Cienkowski, 1996). Nevertheless, it is important for practitioners and researchers to note this finding and to internalize the implication that when patients with the same audiogram report different real world problems, this can be the consequence of different auditory lifestyle demands or different personality makeup, or a combination of both factors.

The results also were consistent with previous studies in showing that patient variables external to the hearing aid, and readily obtained before the hearing aid fitting, account for a substantial proportion of the variance in long-term fitting outcomes. As shown in Table 11, reported hearing problems (specific and overall), previous hearing aid experience, expectations about hearing aid performance, and general aversiveness to loud sounds all were related to the result of the hearing aid fitting reported 6 mo later. Compatible findings have been noted by Jerram & Purdy (2001), Cox et al. (1999), Gatehouse (1994), and Crowley & Nabelek (1996), among others.

In addition, it was determined that patient personality attributes, especially Neuroticism and Agreeableness, were significantly associated with the two wearer-based components of post-fitting outcomes, but not with the device-based component of outcomes (Table 10). However, when prefitting reports about hearing problems, expectations, and sound aversiveness were combined with personality data to predict post-fitting outcomes, the personality data did not add additional independent predictive power. In other words, although patient personality is related to wearer-based self-report outcomes of hearing aid fittings, this relationship is captured by prefitting questionnaires that are already in widespread use. Thus, this investigation did not point to a need to measure personality data to supplement existing variables for prediction of fitting outcomes.

Inadequacy of Traditional Hearing Aid Fitting Variables

Verification of the adequacy of a hearing aid fitting traditionally entails measurement of soft sound audibility, and assessing the match to prescriptive targets for conversational speech levels and maximum output (e.g., Fabry, 2003; Mueller, 1999). Those data were collected in this investigation with the expectation that they would be related to the outcomes of the fitting, especially those outcomes that evaluate the merit of the hearing aid (Device component). This expectation was not fulfilled. It was disturbing to observe that the types of data typically used to quantify and verify hearing aid fittings were only minimally predictive of self-report fitting outcomes. Further, contrary to logical expectations, the hearing aid fitting data were not at all predictive of the device-based component of outcomes. As illustrated in Table 12, only the (patient-based) Success component of outcomes was associated with the hearing aid verification data, and even then, only 10% of the variance in this component was accounted for by the fitting data.

These results strongly suggest that the traditional verification variables (soft sound audibility and prescription match for gain and saturation levels) do not produce data that are highly predictive of better or poorer subjective fitting outcomes when all the hearing aids are broadly appropriate and fittings are conducted using current practice protocols. Even though there were substantial differences among patients on these measures (Figures 2, 3, and 4), and substantial differences in outcomes (Table 6), the two types of data were scarcely related. Nevertheless, it is difficult to accept the proposition that hearing aid technical performance is unrelated to subjective fitting outcomes. Gatehouse & Noble (2004) have proposed that the traditional focus of hearing aid fittings on speech audibility might be too simplistic to encapsulate the value of different amplification schemes in the dynamic acoustical circumstances of everyday living. The results of this study are consistent with that view. These data should motivate researchers to redouble their efforts to seek technical measures of in situ hearing aid performance that are more strongly related to long-term real-world fitting outcomes, especially outcomes that reflect specifically on the merit of the hearing aid (i.e., device-based). Perhaps indices such as real ear distortion (e.g., Cox & Taylor, 1994), or in situ directional function (e.g., Ricketts & Dittberner, 2002), or aspects of temporal processing relative to the patient's abilities (e.g., Gatehouse, Naylor & Elberling, 2003), or measures of effective compression function (e.g., Stone & Moore, 1992) would be more informative than current traditional variables.

Importance of Degree-Unaided-Difficulty and prefitting Aversiveness to Sound

It was noteworthy that higher Aversiveness for unamplified environmental sounds was associated with poorer outcomes in both the Success and Acceptance (wearer-based) outcome components (Table 11). As revealed in Table 4, this variable is pervasively related to personality. This relationship between sound Aversiveness and personality is consistent with previous research in loudness perception (e.g., Stephens, 1970) as well as tolerance for tinnitus (e.g., Scott & Lindberg, 2000). In addition, it is of interest to note the potential parallel between the association in this research between sound Aversiveness and hearing aid Acceptance and a recent report by Nabelek et al. (2003), which suggested that willingness to listen in background noise is a predictor of hearing aid use. Overall, the results of the current investigation suggest that Aversiveness of environmental sounds is an easily-elicited and revealing variable that should alert the practitioner to potential problems with fitting outcomes that might not be associated with the technical performance of the fitted hearing aid. Perhaps such foreknowledge could stimulate preemptive counseling or other measures to address this concern.

Another variable that drew attention as being readily elicited and strongly related to eventual outcomes was Degree-Unaided-Difficulty. As revealed in Table 4, this variable is not related to personality. Further, contrary to logical expectations, it is relatively weakly related to audiogram thresholds (Table 5). However, as shown in Table 11, the Degree-Unaided-Difficulty variable was significantly associated with all three outcome components, but the relationship was complex. Subjects with milder Degree-Unaided-Difficulty scored hearing aids less highly (Device component), but they reported better performance in daily life (Success component) while, at the same time, revealing a less positive attitude towards amplification (Acceptance component). This result attests to the challenge involved in subjective outcome assessment: The outcome of a hearing aid fitting for a given individual is strongly dependent on the outcome component that is measured. Further, this result demonstrates the need for multidimensional assessment of self-report outcomes to derive a more fully realized understanding of the patient's situation.

Impact of Response Bias on Self-Report Data

A tendency toward socially desirable responding was related to several aspects of patient personality (Table 4). It was associated most closely with the Agreeableness personality trait. This is a very plausible association since it indicates that individuals who see themselves as more peace-loving, generous, and non-argumentative are the most likely to portray themselves positively in their responses to questionnaire items. It was also seen that more positive Response Bias was associated with reporting fewer hearing problems in daily life before the hearing aid fitting and also after the fitting (Table 8). However, Response Bias was not associated with the reported extent of hearing aid benefit or hours of daily use. In addition, Response Bias was not related to post-fitting satisfaction except in one aspect: it was weakly (but significantly) associated with satisfaction with self-image (the Personal Image Subscale of the SADL) in that patients with higher Response Bias scores tended to report greater satisfaction on the PI subscale.

These results should be somewhat reassuring to consumers of self-report data because they suggest that Response Bias does not play a major role in determining most domains of fitting outcomes. All in all, the effects of Response Bias were parallel to those of the Agreeableness personality trait, and like the personality data, the effects of Response Bias were fully expressed in prefitting self-reports. Knowledge of Response Bias did not add further information to the prediction of outcomes beyond that available using traditional prefitting variables (Table 12). It should be noted, however, that in this research, subjects knew that their audiologists would not see any individual's outcome reports. It is possible that levels of Agreeableness (and Response Bias) would be more influential in some self-report outcomes in circumstances where this anonymity was not available.

Implications for Research

The results of this investigation have several implications for the design of clinical trials of hearing loss interventions which use self-report data as the dependent variable. In the design phase, researchers should have a clear intention about the type of outcome component that is to be measured. This study has shown that outcome components can be thought of as patient directed (wearer-based) or hearing aid directed (device-based). Studies of the effectiveness of new hearing aids or technologies should probably emphasize self-reports that focus on the device more than the wearer. In the context of the present study, that would include questionnaires that load highly on the Device component (Table 9). Our results suggest that aspects of Satisfaction and direct Benefit are best suited for this application. Item wording ". . . how well does the hearing aid . . ." would be more suitable than ". . . . with the hearing aid, how well do you . . . ." In addition, it can be seen (Tables 11 and 12) that prefitting Expectations, and Degree-Unaided-Difficulty make significant contributions to the Device component of outcome. Consequently, the validity and sensitivity of clinical trials could be optimized by controlling for these variables. Furthermore, the type of service received by the subject also played a role in Device component outcomes. This indicates that researchers should carefully consider the origin of their subjects (e.g., private practice, VA practice, strictly research) to ensure that research findings will be generalizable to the population of interest.

Implications for Practice

The study also carries implications for practitioners who use self-reports to document excellence of services, or to inform fine-tuning or counseling to improve the success of fittings. Although device-based outcomes can have a place in these applications, it is arguable that wearer-based outcomes are more directly relevant to the patient. In the context of the present study, that would include questionnaires that load highly on the Success and Acceptance components (Table 9). Our results suggest that questionnaires that encourage the patient to be introspective about his or her everyday problems (such as aided APHAB or aided HHIE), and measures of daily Use are most appropriate for this type of application. Moreover, practitioners should be aware that numerous variables unrelated to audiogram hearing loss or fitted hearing aid are associated with wearer-based outcomes. These include Degree-Unaided-Difficulty, previous hearing aid experience, and Aversiveness of environmental sounds. Information in Tables 10 and 11 give an indication of the direction and strength of these effects. Allocation of resources sufficient to acquire prefitting self-reports about hearing problems and sound aversiveness will yield clues about likely long term fitting outcomes with competently fitted modern hearing aids.

Implications for Questionnaire Selection

Although many of the most widely used standardized questionnaires were included in this study, there are other existing questionnaires, and new questionnaires frequently appear. The results of this research are not necessarily limited to the actual questionnaires used here. It probably would be possible to gain some insight into the outcome domains and components produced by a new or different questionnaire through evaluation of it at the item content level. If individual items call for patients to be introspective about their feelings or problems, it is likely that the scores will be similar to the wearer-based components in this study. On the other hand, items that direct attention away from feelings and problems and into more neutral territory are more likely to yield device-based data.

CONCLUSIONS

This investigation determined that 20 to 30% of the variance in long-term subjective outcomes of a hearing aid fitting can be accounted for by patient variables that can be measured before the fitting such as reported hearing problems and previous hearing aid experience. For patients with mild to moderately-severe hearing impairment, hearing loss reflected on the audiogram was a negligible or weak predictor of subjective fitting outcomes. Furthermore, traditional measures of hearing aid performance accounted for 10% or less of the variance in subjective outcomes.

Patient personality was associated with reports of hearing problems before the fitting and reported hearing problems remaining after the fitting, but the strength of the relationship between personality and reported hearing problems tended to be less for aided listening than for unaided listening. Outcomes measured in the benefit, use, and satisfaction domains tended to be less strongly related to personality than those that quantify residual problems. Further, a frequently-used method for quantifying benefit was found to be associated with personality in a counter-intuitive direction. This method computes benefit in terms of the difference between reported problems in unaided and aided listening. This difference-benefit approach to measuring outcomes should be used only with considerable caution.

Overall, it was not found that measures of personality data would provide practitioners with additional leverage in predicting probable subjective fitting outcomes, as long as practitioners make use of the types of reports of hearing problems that are already widely available. Several additional patient variables that are easily elicited but relatively under-utilized in practice were found to be quite informative as predictors of fitting outcomes.

The results suggest that it is useful to conceive of self-report outcomes as comprising device-based or wearer-based components. Device-based components focus attention on the merit of the hearing aid, whereas wearer-based components focus attention on the problems and feelings of the patient. It appears that different types of questionnaire items elicit different components. It is plausible that device-based components are more appropriate for research evaluating new amplification technology, whereas wearer-based components might be more relevant for practitioners and patients.

Overall, there was a substantial proportion of variance in self-report outcomes that was not accounted for by the extensive set of variables considered in this study. Further research is called for to identify variables that make independent contributions to subjective outcomes of hearing aid fitting. Particular attention should be given to the exploration of hearing aid technical performance variables that are predictive of fitting outcomes and could serve as a basis for fitting verification.

Appendix

Items used to measure Response Bias (Hays et al., 1989): Each item was answered on a 5-point scale ranging from Strongly Disagree to Strongly Agree

- I am always courteous even to people who are disagreeable.
- There have been occasions when I took advantage of someone.
- I sometimes try to get even rather than forgive and forget.
- I sometimes feel resentful when I don't get my way.
- No matter who I'm talking to, I'm always a good listener.

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