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Predicting Success with Hearing Aids in Everyday Living

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Abstract

Persons with impaired hearing who are candidates for amplification are not all equally successful with hearing aids in daily living. Having the ability to predict success with amplification in everyday life from measures that can be obtained during an initial evaluation of the patient's candidacy would result in greater patient satisfaction with hearing aids and more efficient use of clinical resources. This study investigated the relationship between various demographic and audiometric measures, and two measures of hearing aid success in 50 hearing aid wearers. Audiometric predictors included measures of audibility and suprathreshold distortion. The unaided and aided signal-to-noise ratio (SNR) loss on the QuickSIN test provided the best predictors of hearing aid success in daily living. However, much of this predictive relationship appeared attributable to the patient's age.

Key Words: Age, audiometric variables, everyday success, hearing aids, prediction

Abbreviations: A-AI = aided articulation index; AASC = Army Audiology and Speech Center; A-QSIN = aided QuickSIN score; EXP-C = experience with current hearing aids; EXP-L = lifetime experience with amplification; HAUS = Hearing Aid Usefulness Scale; HINT = Hearing in Noise Test; IOI-HA = International Outcome Inventory for Hearing Aids; OMNI/DIR = switchable omnidirectional/directional; PTA = pure-tone average; REIG = real-ear insertion gain; SADL = Satisfaction with Amplification in Daily Life; SNR = signal-to-noise ratio; U-AI = unaided articulation index; UPD = use per day; U-QSIN = unaided QuickSIN

Sumario

Las personas con trastornos auditivos quienes son candidatas para amplificación no tienen todas el mismo resultado exitoso con el uso de auxiliares auditivos en la vida diaria. Tener la capacidad de predecir el éxito en la vida diaria de la amplificación, a partir de mediciones que pueden ser obtenidas durante la evaluación inicial del sujeto, podría resultar en una mayor satisfacción del paciente con sus auxiliares auditivos y en un uso más eficiente de los recursos clínicos. Este estudio investigó en 50 usurarios de auxiliares auditivos la relación entre varias medidas demográficas y audiométricas, y dos criterios de éxito en el uso de dichos auxiliares. Los elementos de predicción audiométrica incluyeron medidas de audibilidad y de distorsión supra-liminar. La diferencia en la relación señal/ruido (SNR) con y

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sin amplificación a partir de la prueba QuickSIN aportó el mejor elemento de predicción sobre el éxito del auxiliar auditivo en la vida diaria. Sin embargo, mucho de esta relación predictiva parece ser más atribuible a la edad del paciente.

Palabras Clave: Edad, variables audiométricas, éxito cotidiano, auxiliares auditivos, predicción

Abreviaturas: A-AI = Indice de articulación amplificado; ASSC = Centro de Audiología y Lenguaje del Ejército; A-AQSIN = Puntaje QuickSIN amplificado; EXP-C = experiencia con los auxiliares auditivos actuales; EXP-L = experiencia con amplificación durante toda la vida; HAUS = Escala de Utilidad del Auxiliar Auditivo; HINT = Prueba de Audición en Ruido; IOI-HA = Inventario Internacional de Resultado con Auxiliares Auditivos; OMNI/DIR = omnidireccional/direccional intercambiable; PTA = promedio tonal puro; REIG = ganancia de inserción en tiempo real; SADL = satisfacción con la amplificación en la vida diaria; SNR = tasa de relación señal/ruido; U-AI = Indice de articulación sin amplificación; UPD = uso por día; U-QSIN = QuickSIN sin amplificación

Patient success with amplification in daily living is the goal of a hearing aid fitting.[1] To the extent that the patient's needs and expectations for amplification are met, she or he will be satisfied with the hearing aids and find them useful in daily living. In a survey of 3,000 hearing aid owners, Kochkin (2002) found that only 59 percent reported that they were satisfied with the overall performance of their hearing aids. The strongest correlates with patient satisfaction were perceived hearing aid benefit, sound clarity, value, reliability, use in leisure activities, natural sound, and use in noisy or other difficult listening situations. Dissatisfaction with hearing aids makes it more likely that a patient will not use amplification regularly. Cord et al (2002) observed that 20 percent of patients surveyed reported not wearing their hearing aids regularly or at all. In the Kochkin survey, approximately 12 percent of hearing aid owners reported not using their instruments.

Although a variety of hearing aid performance indices has been associated with overall patient satisfaction (Kochkin, 2002), predicting success with amplification prior to hearing aid dispensing has remained an elusive goal. In a study aimed at predicting success with multiple microphone hearing aids, Cord et al (2004) investigated whether the directional advantage measured in a test booth predicted success with directional microphones in everyday listening. Two participant groups were recruited from among patients fit with omnidirectional/directional hearing aids. One group reported obtaining benefit from the directional mode and using it regularly. The other group reported not using the directional mode; that is, they left their hearing aids set in the (default) omnidirectional mode in every listening situations. Using the Hearing in Noise Test (HINT; Nilsson et al, 1994), speech recognition in noise was measured for each microphone mode, and the directional advantage was determined for each patient. Only a small, statistically nonsignificant difference was observed between the mean directional advantage for each group. Further, the two subject groups did not differ significantly in age, pure-tone thresholds, or unaided word-recognition ability.

Hosford-Dunn and Halpern (2001) conducted a large-scale study that related measures that can be obtained prior to hearing aid fitting to success with amplification. They obtained patient-related variables (gender, age, years of hearing aid experience, perceived unaided hearing difficulty, pure-tone average) from 257 patients and related these measures to global satisfaction scores on the Satisfaction with Amplification in Daily Life scale (SADL; Cox and Alexander, 1999). Only age was significantly correlated with the global SADL scale. A modest, but statistically significant, correlation (r = -0.18) was observed. Older patients tended to report less overall satisfaction with amplification than younger patients. Other weak, but statistically significant, correlations were observed between certain patient-related variables and subscale scores on the SADL. However, none of the patient variables alone or in combination provided a strong prediction of hearing aid success.

It seems reasonable to assume that one or more aspects of hearing impairment should be an important determinant in success with amplification. It is noteworthy that the traditional audiometric measures, routinely obtained clinically, appear to be of little use in predicting success with amplification. Neither pure-tone thresholds nor unaided word recognition in quiet correlated well with measures of hearing aid success and satisfaction in studies discussed above. Given that hearing aids function primarily to amplify sound, it is perhaps surprising that measures of hearing loss (reduced sensitivity) generally have not been found to correlate with hearing aid success (Mulrow et al, 1992; Schum, 1992; Jerram and Purdy, 2001). It may be that there is little variance across patients in the ability of hearing aids to restore audibility, at least for patients with mild-to-severe reductions in threshold sensitivity. That is to say, audibility may be sufficiently restored to most hearing aid users, so this factor cannot predict everyday success. It would appear, therefore, that other sequela of hearing impairment may account for the variability in patient success with amplification.

Plomp (1978) argued that the effects of hearing impairment on speech understanding may be characterized as a combination of attenuation and distortion factors. The former corresponds to the loss of threshold sensitivity and, therefore, may be readily addressed via amplification. The distortion factor is equivalent to a decrease in the signal-to-noise ratio (SNR), which is generally unchanged with amplification, at least for conventional omnidirectional microphone hearing aids. Persons with impaired hearing typically require a more favorable SNR to achieve acceptable speech understanding in a given amount of background noise than do persons with normal hearing (Plomp, 1978), although there is considerable variability across patients.

Killion (2002) further characterized Plomp's distortion factor as a loss of channel capacity; although the speech cues may be audible, they are distorted when they reach the brain and, therefore, are not entirely useful. He proposed that the distortion factor may be quantified for individual patients by the "SNR loss," defined as the increase in SNR required for a person with impaired hearing to achieve 50 percent correct recognition compared to a person with normal hearing.

This study attempted to identify audiometric or other patient-related variables that can be obtained prior to hearing aid dispensing, which may be used to predict success with amplification in everyday living. Two measures of hearing aid success were related to a number of predictor variables, which included measures of audibility (Plomp's attenuation factor) and SNR loss (distortion factor), as well as patient demographic and hearing aid experience/use variables.

METHOD

Participants Sample

Fifty adult male patients seen consecutively by the first author for routine hearing aid checks at the Army Audiology and Speech Center (AASC) during a ten-month period were included in the study. Their mean age was 72.1 years (SD: 12.3; range: 49–94). Patients were heterogeneous with regard to etiology of the hearing impairment, severity, audiometric configuration, and site of lesion, although the typical patient had a bilateral, symmetrical, sloping sensorineural hearing loss. Participants had worn their current hearing aids an average of 19.5 months (range: 2–72) and used them an average of 8.6 hours per day (range: 1–18). Further, they had used some form of amplification for an average of 5.3 years (range: 2 mo. to 20 yr.). For nine of the participants, their current hearing aid was their first experience with amplification. The mean audiogram of the 50 participants is shown in Figure 1.

Hearing Aid Fittings

Hearing aids were fit according to individual patient needs, and a variety of instrument manufacturers and models were

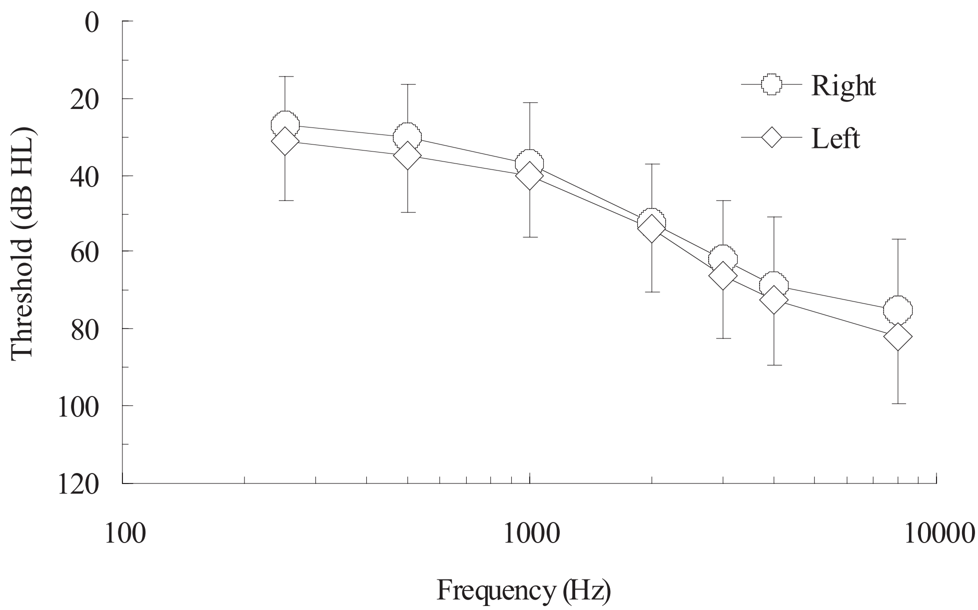

Figure 1. Mean audiogram for the 50 participants. Error bars indicate one standard deviation.

prescribed. Thirty-nine participants were fit bilaterally, and the remaining 11 participants were fit unilaterally. The distribution of patients according to hearing aid style, processor type, microphone option, and bilateral versus unilateral fittings are summarized in Table 1. For patients fit bilaterally, both ears were fit with the same processor type and microphone option.

Predictive Measures

The predictive measures are summarized in Table 2. The audiometric measures were routinely obtained at the time of the hearing aid evaluation/fitting of the participants' current hearing aids. These included three measures assumed to reflect audibility (pure-tone average [PTA], unaided articulation index [U-AI], aided articulation index [A-AI]) and two measures of distortion (unaided QuickSIN [U-QSIN], aided QuickSIN score [A-QSIN]). The sixth audiometric predictor variable (NU-6) is a traditional measure of suprathreshold word recognition in quiet and may reflect both audibility and distortion effects. The demographic (age) and hearing aid use (experience with current hearing aids

Table 1. Distribution of Patient Fittings (n = 50) According to Instrument Categories

	Processor Type			Microphone		Ear(s) Fit	
	Nonprogrammable Analog	Digitally Programmable Analog	Digital Signal Processor	Omnidirectional	Switchable Omnidirectional/ Directional	Unilateral	Bilateral
Behind-the-Ear	0	2	2	0	4	0	4
Half Shell	0	5	0	2	3	0	5
Canal	1	4	13	4	14	5	13
Completely-in-the-Canal	2	17	4	23	0	6	17
Total (%)	3 (6%)	28 (56%)	19 (38%)	29 (58%)	21 (42%)	11 (22%)	39 (78%)

Table 2. Predictive Measures

Predictive Measures	Description
Age	Patient's age in years
PTA	Pure-tone average (1, 2, 4 kHz) in better ear (dB HL)
U-AI	Unaided Articulation Index (0–100; "count the dots")
A-AI	Aided Articulation Index (0–100; "count the dots")
NU-6	Recorded NU-6 in quiet at 80 dB HL in better ear (%)
U-QSIN	Unaided QuickSIN (SNR loss in dB)
A-QSIN	Aided QuickSIN (SNR loss in dB)
EXP-C	Experience with current hearing aids (months)
EXP-L	Lifetime experience with amplification (years)
UPD	Use of hearing aid per day (hours)

[EXP-C], lifetime experience with amplification [EXP-L], use per day [UPD]) data were obtained at the time of the hearing aid check.

The "count the dot" method of Mueller and Killion (1990) was used to obtain an Articulation Index-based estimate of unaided and aided audibility. The AI represents the proportion of speech cues that, on average, are audible to the listener. Pure-tone thresholds in the better ear (or in the aided ear for unilateral fits) were used to estimate each participant's unaided AI. To estimate the aided AI, the real-ear insertion gain (REIG, 65 dB SPL input) was subtracted from the unaided thresholds to obtain the aided thresholds.

The QuickSIN test (2001) was used to assess the SNR loss, both unaided and aided with the hearing aid(s) prescribed for the patient. Typically, these tests were administered at the time of the hearing aid fitting. However, for participants fit with their current hearing aids prior to 2001, QuickSIN test results were not available. In these cases, the unaided and aided QuickSIN tests were administered during the follow-up appointment. Lists of six sentences, each containing five key words and mixed with a four-talker babble, are presented to the participants in the sound field at 70 dB HL from a single loudspeaker positioned at 0° azimuth. One sentence is presented at each of six SNRs from +25 dB to 0 dB, in 5 dB steps, resulting in 30 key words per list. The number of key words correctly repeated is subtracted from 25.5. The numerical difference is reported as the SNR loss in decibels and reflects the patient's SNR deficit compared to persons with normal hearing. For each test condition (unaided, aided), two lists were presented and averaged to obtain the SNR loss. For participants fit with switchable. omnidirectional/directional hearing aids, the A-QSIN test was administered in the omnidirectional mode.

Outcome Measures

Two outcome measures were administered during the follow-up appointment to assess postfitting success with hearing aids. They were administered a minimum of eight weeks postfitting. The International Outcome Inventory for Hearing Aids (IOI-HA, Cox and Alexander, 2002) is a self-assessment inventory that evaluates multiple outcome domains, such as use, benefit, satisfaction, and quality of life. A rating of 1–5 is assigned to each of the seven questions, with higher ratings indicating a better outcome. Therefore, a patient's overall score can vary from 7 to 35. The Hearing Aid Usefulness Scale (HAUS) is used at the AASC to obtain an estimate of the patient's overall usefulness of the hearing aid(s) in daily living on a scale from 1–100, where 1 indicates "My hearing aid(s) are of no use to me" and 100 indicates "My hearing aid(s) are so useful that they meet every need I have for them."

Procedures

All predictive and outcome measures were obtained in conjunction with routine clinic visits by the participants. The audiometric data were obtained at the time the participants' current hearing aids were fit. Testing was conducted in a two-room test suite, using calibrated equipment and standard testing procedures. The IOI-HA and HAUS were administered during a subsequent clinic visit. For patients who had recently been fit with their current hearing aids, this was a scheduled follow-up hearing

Table 3. Descriptive Statistics for the Predictive Measures

	Age	PTA	U-AI	A-AI	NU-6	U-QSIN	A-QSIN	EXP-C	EXP-L	UPD
Mean:	72.1	53.3	.26	.50	90.3	6.3	4.6	19.5	5.3	8.6
SD:	12.3	12.4	.19	.17	12.1	3.7	3.0	19.8	4.7	4.2

aid check. For other participants, the hearing aid check was part of a routine hearing evaluation.

RESULTS

Relationship among Predictive Measures

The mean scores and standard deviations for each of ten predictive measures are shown in Table 3. The standard deviations reveal that there was substantial variability across the 50 patients for each of the predictor variables.

Table 4 presents the correlation matrix for the ten predictive measures. Statistically significant (p < .05, p < .01) correlations are indicated by one or two asterisks. Significant correlations were observed among all six audiometric measures (PTA, U-AI, A-AI, NU-6, U-QSIN, A-QSIN), and all were in the expected direction. For example, higher pure-tone averages were associated with lower NU-6 word-recognition scores (r = -.52). Within the six audiometric predictor variables, correlations were highest among the three audibility measures (PTA, U-AI, A-AI) and among the two distortion measures (U-QSIN, A-QSIN) and the NU-6 scores. Of the hearing aid use variables (EXP-C, EXP-L, UPD), statistically significant correlations were most frequently observed between lifetime experience with hearing aids and other predictor variables. However, most of these significant correlations appeared to be explained by the expected significant relationship between lifetime experience and the patient's age (r = .48). For example, a significant positive correlation (r = .34) was observed between pure-tone average, which generally is expected to increase with age, and lifetime experience with amplification. Similarly, a significant negative correlation (r = -.39) was observed between lifetime experience with hearing aids and NU-6 scores, which are more likely to decrease with age. The participants' experience with their current hearing aids did not correlate significantly with any of the other predictor variables. Finally, hours of hearing aid use per

Table 4. Correlations among the Predictive Measures

	Age	PTA	U-AI	A-AI	NU-6	U-QSIN	A-QSIN	EXP-C	EXP-L	UPD
Age	---	.39**	-.36*	-.27	-.30	.59**	.44**	.25	.48**	-.12
PTA		---	-.81**	-.63**	-.52*	.53**	.56**	.16	.34*	-.39**
U-AI			---	.80**	.40**	-.52**	-.52**	-.11	-.33*	.28*
A-AI				---	.38**	-.47**	-.40**	.01	-.26	.21
NU-6					---	-.69**	-.64**	-.07	-.39**	.12
U-QSIN						---	.75**	.05	.55**	-.10
A-QSIN							---	.11	.31*	-.19
EXP-C								---	.44**	-.04
EXP-L									---	.20
UPD										---

**p < .01
*p < .05

day correlated significantly only with two audibility measures—the pure-tone average and the unaided articulation index—such that increased use of the hearing aids was associated with greater (unaided) loss of audibility.

In addition to the significant correlations observed among the six audiometric measures, scores on both the unaided and aided QuickSIN were significantly correlated with age (r = .59, r = .44, respectively). Notably, the relationship between age and the QuickSIN scores was not primarily attributable to the increase in pure-tone sensitivity that often accompanies aging. For example, with the pure-tone average partialled out, the partial correlation between age and the U-QSIN is only slightly reduced (r = .48). Hence, the deficit in speech understanding in background noise associated with aging appears largely attributable to factors other than elevated pure-tone thresholds.

Relationship between Instrument/Fitting Categories and Outcome Measures

The mean IOI-HA score of the 50 participants was 29.1 (SD: 3.5), and the mean HAUS rating was 77.5 (SD: 10.6). As was the case for the predictive measures, the standard deviations for both outcome measures reveal substantial variability across the participants. Figures 2 and 3 show mean scores on the two outcome measures according to processor type, microphone option, and fitting. The only statistically significant difference observed was between the mean IOI-HA scores of the 29 participants fit with conventional omnidirectional microphone hearing aids and the 21 participants wearing switchable omnidirectional/directional microphone hearing aids. Participants fit with the latter microphone option tended to obtain slightly higher IOI-HA scores than patients fit with hearing aids having only omnidirectional microphones.

Relationship between Predictive and Outcome Measures

The correlation between the IOI-HA and HAUS was r = .85, suggesting that both outcome measures reflect the same underlying dimension of hearing aid success. The correlation between each of the predictive measures and the two outcome measures are shown in Table 5. None of the three audibility measures (PTA, U-AI, A-AI), or the NU-6 scores, correlated significantly with either outcome measure. In contrast, correlations between the two distortion measures (U-QSIN, A-QSIN) and each outcome measure were statistically significant. Greater hearing aid satisfaction/benefit on the IOI-HA and greater hearing aid usefulness on the HAUS was associated with smaller SNR losses on the QuickSIN. None of the three hearing aid use predictor variables (EXP-C, EXP-L, UPD)

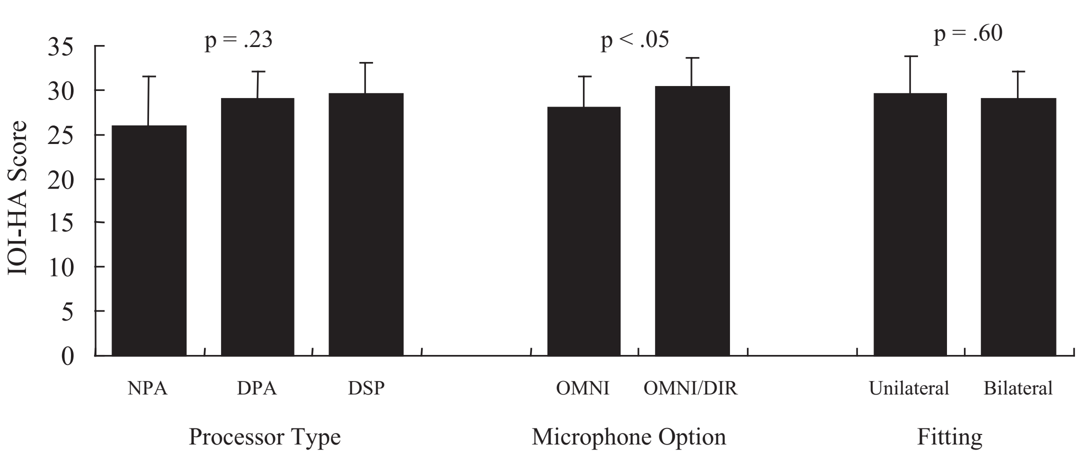

Figure 2. Mean scores on the IOI-HA according to processor type, microphone option, and fitting.

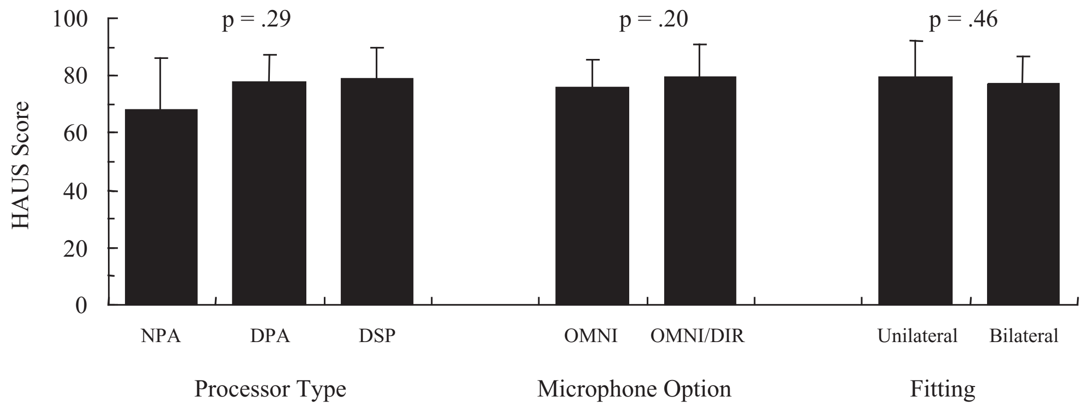

Figure 3. Mean scores on the HAUS according to processor type, microphone option, and fitting.

correlated significantly with the HAUS ratings. Significant correlations were observed between the IOI-HA scores and the EXP-C and UPD variables (r = -.29, r = .47, respectively). Patients who reported greater satisfaction/benefit on the IOI-HA tended to use their hearing aids more. However, they tended to have less experience with their current hearing aids as well; that is, they tended to own their current hearing aids for a shorter period of time, although this was a relatively weak relationship. The latter finding may reflect a "halo effect" from new hearing aids, a tendency for older hearing aids not to function as well as newer instruments, or a combination of these factors. Because EXP-C (experience with current hearing aids) was also the time between the hearing aid fitting and administration of the outcome measures, it is also the case that reported success with amplification tended to decrease with time, suggesting, therefore, that acclimatization effects were not a major influence on reported success with amplification.

In addition to the significant correlations observed between the two QuickSIN SNR loss scores and the IOI-HA and HAUS ratings, the participant's age was significantly correlated with both outcome measures, such that success with amplification tended to decrease with increasing age. Noting that age was significantly correlated with scores on both the U-QSIN and the A-QSIN (see Table 4), partial correlations were computed between both the IOI-HA scores and HAUS ratings and the QuickSIN scores, with the effects of age partialled out. The partial correlation between the U-QSIN and the IOI-HA dropped to r = -.14 and was not statistically significant, as was the partial correlation between the A-QSIN and IOI-HA scores (r = -.23). Similarly, the partial correlations between the unaided and aided QuickSIN scores and the HAUS dropped to r = -.18 and r = -.25, respectively, and neither was statistically significant. It appears, therefore, that much of the predictive relationship between the QuickSIN and hearing aid success in everyday life is attributable to the effects of age.

Table 5. Correlations between the Predictive Measures and Two Outcome Measures

	Age	PTA	U-AI	A-AI	NU-6	U-QSIN	A-QSIN	EXP-C	EXP-L	UPD
IOI-HA	-.40**	-.20	.09	.06	.13	-.34*	-.37**	-.29*	-.10	.47**
HAUS	-.45**	-.10	.09	.15	.05	-.39**	-.40**	-.24	-.14	.26

**p < .01
*p < .05

DISCUSSION

Patient age, audiometric measures, and measures of hearing aid experience and use were correlated with measures of hearing aid success in daily life obtained from 50 adult hearing aid wearers in an attempt to identify predictors of hearing aid success. The audiometric variables included measures of audibility and measures of suprathreshold distortion.

Perhaps the first observation that can be made of the data is that there was substantial variability in the outcome measures across participants. Patients differ considerably in the degree of success that they experience with amplification in daily living. Therefore, it is of clinical importance to identify measures that might be obtained during the hearing aid evaluation that would predict the success that a patient is likely to experience with hearing aids. Although such measures might not necessarily be used to determine whether or not a hearing aid is recommended, it would assist in this decision and would certainly be helpful in counseling the patient regarding realistic expectations for amplification.

Although statistically significant correlations were observed among all six audiometric variables (see Table 4), these data were consistent with the view that two dimensions of hearing impairment exist, that is, an audibility dimension and a distortion dimension. Highest correlations were observed among the audiometric measures within each category. Moderately strong correlations were observed among the three audibility measures. However, these measures were virtually unrelated to either of the outcome measures. As suggested earlier, at first glance, this may seem unexpected. Hearing aids function primarily to amplify sound, and certainly, the patient's most fundamental hearing need is audibility. Moreover, the variability observed in the audibility measures indicates that participants differed considerably in their requirements for amplification. The lack of a relationship between the audibility measures and the success measures suggests that the amplification prescribed for these patients generally did similarly well in restoring audibility. If this were the case, it should not be surprising that measures of audibility did not predict everyday success with amplification.

In contrast to the measures of audibility, the two measures of distortion (U-QSIN, A-QSIN) were significantly correlated with each of the hearing aid outcome measures. At first glance, this might also appear somewhat surprising in that conventional hearing aids generally do not compensate for suprathreshold distortion effects, which include central auditory processing and cognitive deficits, as well as peripheral influences. If it is assumed that the hearing aids provided little or no compensation for the distortion effects of the patients' hearing impairments, the significant correlations between the two QuickSIN measures and the IOI-HA and HAUS ratings must be attributable to variability in the inherent (unaided) SNR losses of the patients. Support for this perspective is provided by the relatively high correlation between the

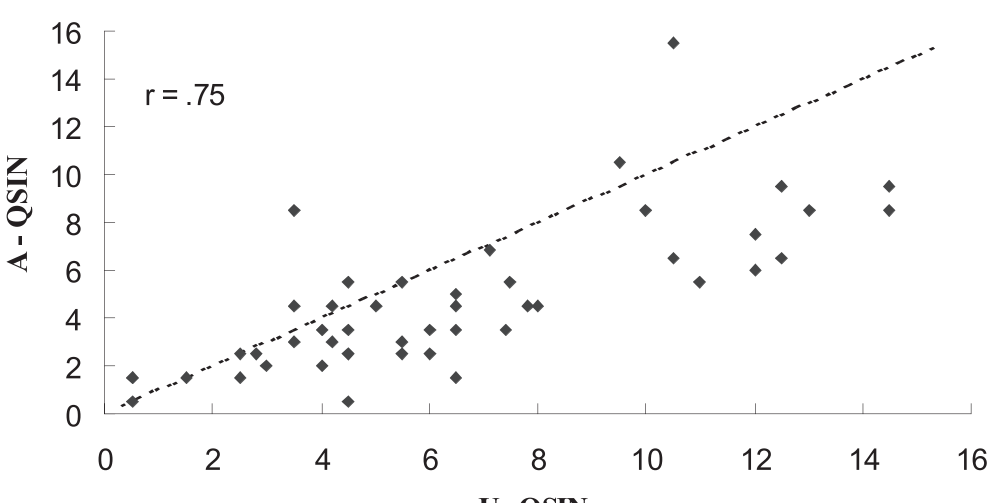

Figure 4. Scatterplot showing the relationship between the U-QSIN and A-QSIN predictor variables.

unaided and aided QuickSIN scores (r = .75). This relationship is shown in Figure 4, which shows a scatterplot of these two variables. With the exception of two outliers who obtained substantially greater SNR losses aided than unaided, there was a quite systematic relationship between the U-QSIN and A-QSIN scores. Patients who tended to have large unaided SNR losses tended to maintain those large SNR losses when wearing their hearing aids. In this regard, it should be noted that the mean SNR loss for the A-QSIN was somewhat (1.7 dB) smaller than for the U-QSIN (see Table 3), and this mean difference was statistically significant ($t = 4.75$, $p < .01$). This slightly improved mean performance in the aided condition is reflected in the preponderance of data points in Figure 4 below the main diagonal. However, it is likely that this difference reflects improved audibility of the test sentences in the aided condition, rather than an actual improvement in the SNR resulting from amplification. Additionally, if the hearing aids actually improved the patient's ability to understand speech in background noise, it is reasonable to expect that the difference between the unaided and aided QuickSIN scores (i.e., the reduction in the SNR loss due to amplification) would predict success with amplification in everyday living. The correlations of the difference between the unaided and aided QuickSIN scores and the IOI-HA and the HAUS ratings were $r = -.11$ and $r = -.08$, respectively. Both were not significant and suggest that the hearing aids did little to improve the patient's inherent ability to understand speech in noise.

Although hearing aids generally do not compensate for suprathreshold distortion effects, a possible exception is directional microphone instruments, which offer the potential to improve the SNR at the listener's ear. Such an improvement would not be observed for the QuickSIN measures because participants fit with switchable omnidirectional/directional hearing aids were tested only in the omnidirectional mode, and, in any case, the test sentences and competing noise are both presented from a single loudspeaker. However, participants fit with this technology could have experienced improved SNRs in the directional mode in some everyday listening situations. In this regard, it is notable that those participants fit with switchable omnidirectional/directional hearing aids obtained a statistically significant higher mean score on the IOI-HA than did the participants wearing hearing aids equipped with only omnidirectional microphones, although the actual difference was relatively small (see Figure 2). The importance of this finding is difficult to interpret because it is not known, except anecdotally, if these patients used the directional mode regularly or appropriately in everyday living (see Cord et al, 2002; and Walden et al, 2004, for a discussion of this issue.) Nevertheless, the slightly higher mean scores on the IOI-HA for patients fit with hearing aids equipped with directional microphones provides at least some evidence that they may be useful in addressing the suprathreshold distortion effects of hearing impairment in everyday listening.

Overall, the results suggest that suprathreshold distortion effects of hearing impairment are the best predictors of everyday success with amplification. Patients who require more favorable SNRs to understand speech are less likely to be successful with hearing aids than patients who can understand speech at more normal SNRs. Unfortunately, these distortion effects tend to increase with age. It is well known that a variety of suprathreshold auditory processing abilities diminish with age, including frequency and intensity discrimination (He et al, 1998) and temporal processing (Fitzgibbons and Gordon-Salant, 1994, 1995; Snell, 1997). Further, Divenyi and Haupt (1997) found that susceptibility to interference from background babble and reverberation was a significant factor in the decline in auditory function with age, and an important determinant in the speech recognition performance of elderly listeners.

Previous authors have suggested that older patients may experience considerably less benefit from amplification than might be predicted based on traditional measures of threshold sensitivity and speech recognition in quiet (Stach et al, 1985), and that this decreased performance with hearing aids may be due to age-related changes in central auditory processing (Hayes and Jerger, 1979). It is perhaps not surprising then that the two QuickSIN scores provided the best predictors of everyday success with hearing aids and that most of this predictive relationship was associated with age.

Although the statistically significant predictive relationship that exists between age and hearing aid success provides a somewhat pessimistic picture of hearing aid use in the elderly, it should be noted that age explained only a small part of the variance in the hearing aid outcome measures. Many elderly patients experience considerable success with amplification. Conversely, some younger patients may experience limited success. Although the QuickSIN measures of SNR loss appear to provide useful information to assist the audiologist in hearing aid fitting and counseling decisions (Taylor, 2003), it is likely that other variables, in addition to suprathreshold distortion effects, contribute to everyday success with amplification.

Acknowledgment. All data of this study were obtained in conjunction with normal patient care. Every participant signed a Privacy Act statement acknowledging that his clinical data may be used for non-health-care purposes, including compilation of statistical data for research purposes. The opinions and assertions presented are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. The technical assistance of Van Summers and Mary Cord is gratefully acknowledged.

NOTES

1. The term "success" is used as a global hearing aid outcome measure and is intended to encompass multiple outcome domains, such as benefit, satisfaction, and quality of life issues. Greater success suggests that the hearing aids are meeting more of the patient's needs and expectations for amplification.

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