# PREDICTING HEARING AID USEFULNESS

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## INTRODUCTION

Hearing aids are not equally useful to every hearing-impaired patient who is a candidate for amplification. The ability to predict success with amplification in everyday living 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 retrospective study investigated the relationships among various demographic and audiometric measures routinely obtained from patients at the Army Audiology and Speech Center, and two measures of hearing aid success. Of the measures considered, the patient's age was the best predictor of success with amplification.

## METHOD

### Subjects

The subjects of this study were 36 patients seen for a hearing aid evaluation or hearing aid check by the first author.

### Hearing Aid Fittings

- Patients were fit with a variety of hearing aid circuits and models.
- 29 bilateral; 7 unilateral
- 24 digitally programmable analog; 8 digital; 4 non-programmable
- 26 omnidirectional only; 10 switchable omnidirectional/directional

### Predictive Measures

The following clinical measures were recorded from each patient's clinic chart:

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

### Outcome Measures

Two measures of hearing aid success were obtained for each patient:

*International Outcome Inventory for Hearing Aids (IOI-HA)*. The IOI-HA (Cox et al., 2000) is a self-assessment inventory consisting of seven questions that evaluate patient satisfaction with and benefit from amplification [e.g., Item 4: "Considering everything, do you think your present hearing aid(s) is worth the trouble?"]. A rating of 1-5 is assigned to each of the seven questions, with higher ratings indicating greater satisfaction/benefit. Therefore, a patient's overall score can vary from 0 to 35.

*Hearing Aid Usefulness Scale (HAUS)*. The HAUS is the patient's global estimate of the usefulness of his/her 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.*"

### Procedure

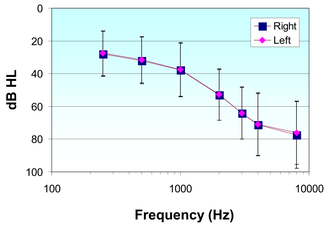
Patients were seen for an initial hearing aid evaluation or hearing aid check in the Audiology Clinic, Army Audiology & Speech Center. Audiometric testing was conducted using standard equipment and testing procedures. For current hearing aid users (i.e., hearing aid check), the IOI-HA was administered at the time of the clinic visit and the patient was asked to provide a global rating of their overall hearing aid usefulness (HAUS). Patients who were fit with amplification following a diagnostic evaluation were administered the IOI-HA and provided their global rating (HAUS) during a routine follow-up visit, 1-2 months post-fitting, or were contacted by telephone to obtain the outcome measures.

## RESULTS

### Patient Demographics

- Mean age: 72.5 years (SD: 12.1; range: 53-94).
- Heterogeneous with regard to etiology, severity, audiometric configuration, and site of lesion.
- Mean use of current hearing aids: 22.6 months (SD: 20.7; range: 1-72)
- Mean lifetime use: 5.6 years (SD: 4.9; range: 1-20)
- Mean hours of use per day: 7.9 hours (SD: 4.4; range: 1-18)
- Mean audiogram shown in **Figure 1**

**FIGURE 1. Mean audiogram of the 36 patients (error bar = 1 SD).**




### Relationship Among Predictive Measures

**Table 1.** Mean scores and standard deviations for each predictive measure. Standard deviations reveal substantial variability across the 36 patients for each measure.

Predictive Measures

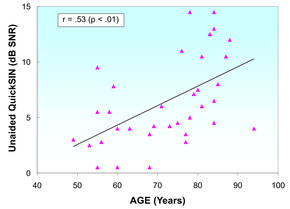
| | AGE (years) | PTA (dB HL) | NU-6 (%) | U-SIN (dB SNR) | A-SIN (dB SNR) | U-AI | A-AI | EXP-C (months) | EXP-L (years) | UPD (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| M: | 72.5 | 55.3 | 89.8 | 6.5 | 5.0 | .23 | .49 | 22.6 | 5.6 | 7.9 |
| SD: | 12.1 | 12.4 | 13.4 | 4.0 | 3.2 | .18 | .17 | 20.7 | 4.9 | 4.4 |

**TABLE 2. Correlations among the 10 predictive measures. Correlations that exceeded the .99 and .95 confidence levels (one-tailed) are indicated in red (p < .01) and green (p < .05), respectively.**

| | AGE (years) | PTA (dB HL) | NU-6 (%) | U-SIN (dB SNR) | A-SIN (dB SNR) | U-AI | A-AI | EXP-C (months) | EXP-L (years) | UPD (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| AGE | --- | .30 | -.22 | .53 | .37 | -.22 | -.19 | .12 | .45 | .04 |
| PTA | | --- | -.54 | .51 | .57 | -.78 | -.66 | .03 | .23 | -.32 |
| NU-6 | | | --- | -.68 | -.64 | .42 | .38 | .01 | .40 | .02 |
| U-SIN | | | | --- | .74 | -.51 | -.47 | -.08 | .54 | .04 |
| A-SIN | | | | | --- | -.51 | -.40 | -.03 | .27 | -.12 |
| U-AI | | | | | | --- | .84 | .04 | -.20 | .19 |
| A-AI | | | | | | | --- | -.08 | .17 | -.14 |
| EXP-C | | | | | | | | --- | .40 | .06 |
| EXP-L | | | | | | | | | --- | .33 |
| UPD | | | | | | | | | | --- |

- Statistically significant, but generally modest, correlations observed among the six audiometric measures (PTA, NU-6, U-SIN, A-SIN, U-AI, A-AI), all in the expected direction (e.g., Poorer signal-to-noise ratios were associated with lower NU-6 word recognition scores.)
- Highest correlations observed between the PTA in the better ear and the unaided AI score (r = -.78) and between the unaided and aided AI scores (r = .84).
- Scores on both the unaided and aided QuickSIN significantly correlated with age (r = .53 and .37, respectively).

**FIGURE 2. Correlation between patient age and unaided QuickSIN score.**




- Relationship between age and the QuickSIN scores are not attributable mainly to the decrease in pure tone sensitivity that often accompanies aging. When the pure tone average is partialled out, the partial correlation between age and the unaided QuickSIN is only slightly reduced (r = .46; p < .01).
- Hence, the deficit in speech understanding in background noise associated with aging appears to be attributable to factors other than elevated pure tone thresholds.

### Relationship Between Predictive and Outcome Measures

The mean scores and standard deviations for the two outcome measures are given in **Table 3**. The standard deviation for each measure reveals substantial variability across the 36 patients. The correlation between the IOI-HA and the HAUS, across the 36 patients, was r = .88, suggesting that both outcome measures reflected the same underlying dimension of hearing aid success.

**TABLE 3. Means and standard deviations for the two outcome measures.**

| | IOI-HA (7-35) | HAUS (1-100) |
|---|---|---|
| M: | 28.5 | 76.8 |
| SD: | 3.7 | 11.6 |

**TABLE 4. Correlations between each of the predictive measures and the two outcome measures. Correlations that exceeded the .99 and .95 confidence levels (one-tailed) are indicated in red (p <.01) and green (p <.05), respectively.**

| | AGE (years) | PTA (dB HL) | NU-6 (%) | U-SIN (dB SNR) | A-SIN (dB SNR) | U-AI | A-AI | EXP-C (months) | EXP-L (years) | UPD (hours) |
|---|---|---|---|---|---|---|---|---|---|---|
| IOI-HA | -.33 | -.06 | .07 | -.26 | -.31 | -.09 | .00 | -.23 | -.04 | .39 |
| HAUS | -.41 | .01 | -.01 | -.35 | -.39 | -.05 | .06 | -.21 | -.10 | .14 |

- Scores on both of the outcome measures significantly correlated with age such that *success* with amplification tended to *decrease with increasing age.*
- Statistically significant correlations observed between the HAUS score and both the unaided and aided QuickSIN scores (r = -.35 and -.39, respectively). In each case, *greater* hearing aid *usefulness* on the HAUS was associated with *lower SNR* on the QuickSIN.
- Because age was significantly correlated with scores on both QuickSIN measures (see **Table 2**), partial correlations were computed between the HAUS scores and these two predictive variables, with the effects of age partialled out. The partial correlation of the unaided QuickSIN and the HAUS dropped to r = -.17, and was not statistically significant.
- The partial correlation of the aided QuickSIN and the HAUS was -.28. Although this just achieved statistical significance at the .05 level, less than 8% of the variance in the HAUS scores was accounted for by the aided QuickSIN scores.
- Much of the predictive relationship observed between the QuickSIN and hearing aid usefulness appears attributable to the effects of age.
- A significant correlation was observed between the IOI-HA and the aided QuickSIN scores. Again, with the effects of age partialled out, there was virtually no relationship between these two measures.

## DISCUSSION

This study explored whether self-assessed success with amplification one month or more following fitting could be predicted from measures that can be obtained at the time of the initial diagnostic evaluation. Two outcome measures of hearing aid success were correlated with a number of audiometric measures, as well as with the patient's age and use of amplification.

**Finding**: The significant correlations observed between age and both of the QuickSIN measures suggests that *as patients age, a more favorable SNR* is required to achieve an acceptable level of speech understanding.

- Knowing that persons with impaired hearing as a group (i.e., regardless of age) require more favorable SNRs to understand speech compared to persons with normal hearing, the above finding suggests that *older* patients with impaired hearing will have an *especially* difficult time functioning in the presence of background noise.

**Finding**: No relationship was observed between any of the measures of acuity/audibility (PTA, U-AI, A-AI) and hearing aid success. Similarly, word recognition in quiet was unrelated to success with amplification.

- Although measures of acuity (e.g., pure-tone sensitivity) and audibility (unaided and aided AI) are important when prescribing hearing aids, *degree of hearing loss alone does not predict* success with amplification in everyday living (at least within the range of hearing losses included in this study).
- The most commonly administered diagnostic tests (pure tones and monosyllabic word recognition in quiet) provide virtually no indication of the degree of success that the patient will achieve with amplification in everyday living.
- None of the standard audiometric measures had a strong predictive relationship with either of the outcome measures, suggesting that *variables in addition* to those measured in this study contribute to success with amplification in everyday living.

The limited sample size (n = 36) prevented more sophisticated statistical treatments (e.g., multiple correlation analyses) of the data to determine whether combinations of variables might better predict self-assessed hearing aid success in everyday living. Nevertheless, these data suggest that only a modest relationship, at best, exists between a number of clinical measures suggested to predict hearing aid usefulness and the patient's actual satisfaction with amplification.

## REFERENCES

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