The Situational Hearing Aid Response Profile: An Update

Marc Brennan, Ryan McCreery, Dawna Lewis, Jody Spalding, Thomas Creutz, Judy Kopun, Patricia Stelmachowicz
Boys Town National Research Hospital, Omaha, NE 68131

INTRODUCTION

Problem: How can we estimate hearing-aid output for the speech-input levels that infants, children and adults experience (e.g. classroom, cradle position)?

Approach: Use real-ear measurements of hearing-aid output for standardized stimuli to estimate output for a variety of speech-input levels.

Situational Hearing Aid Response Profile (SHARP)

SHARP is a computer program that:
- Estimates hearing-aid output for 13 long-term average speech spectra (LTASS) that represent a variety of communication situations.
- Accepts audiometric data from a range of transducers.
- Allows comparison of audibility for unaided and aided speech.
- Accounts for linear and WDRC processing.

History. SHARP was introduced in 1994 and the latest version (v6) was released 2002. The user is required to manually enter hearing thresholds and hearing-aid parameters (output level, compression characteristics).

SHARP v7

SHARP Version 7 incorporates the following features:
- ***Real-ear import:*** Can import real-ear measurements from the Audioscan Verifit.
- ***Hearing aid output:*** Estimates of hearing-aid output for different listening situations are now predicted using linear regression.
- ***Aided Audibility Index (AAI):*** The calculation of the AAI has been updated to incorporate the latest speech intelligibility index standard (ANSI, 1997) with one modification. The dynamic range is estimated from the predicted minimum and peak level for speech after amplification.

Interface. See Figure 1:
1. Data import from the Verifit:
   a. On the Verifit save the data to either a network or USB drive.
   b. In SHARP, select Browse, navigate to the saved file and open.
2. Parameters:
   a. Select the ear (Left, Right)
   b. Select the talker (Male, Female, Child). This adjusts the SPL used for the computation of the LTASS.
   c. Select Unaided or Aided.
   d. Condition. Used to select the listening situation. Most are self explanatory. VS, VM, and VL are LTASS at 55, 65, and 75 dB SPL, respectively.
3. Band importance function / passage:
   a. The band importance function used for computation of the AAI can be based on either the standard, nonsense syllables, or sentences.
   b. The passage used when measuring the hearing-aid output with the Verifit is specified here (Carrot, Ear, ISTA, or Female). The program assumes the input level across frequency based on the selected passage.
4. Select *enter* to manually enter the real-ear data.
5. Select *numbers* to obtain a table of the SPLs that are shown in the display.
6. AAI. Calculated as described above.
7. Legend

Hearing-aid output. The hearing-aid output for the different listening situations is estimated using the following procedure:
- Verifit XML file provides hearing-aid output for 1/12 octaves from 200 Hz to 8000 Hz for minimum, LTASS, and peak.
- SHARP interpolates from 1/12 to 1/3 octaves because the estimated talker levels are specified in 1/3 octave levels.
- Linear regression is computed multiple times for each 1/3 octave band. The input levels are the predictor variables. The output levels are the dependent variables. From this we get linear regression equations (y-intercept, slope) for each 1/3 octave band.
- SHARP then predicts the output for the different listening situations using the linear regression equations.

FIGURES

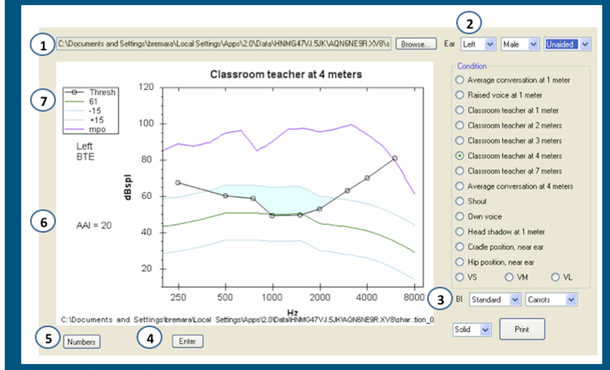

Figure 1: Unaided Classroom 4m

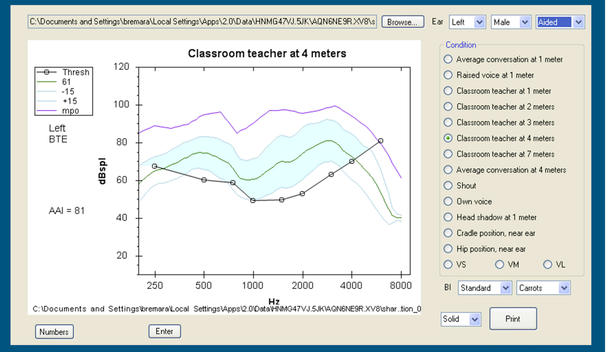

Figure 2: Aided Classroom 4m

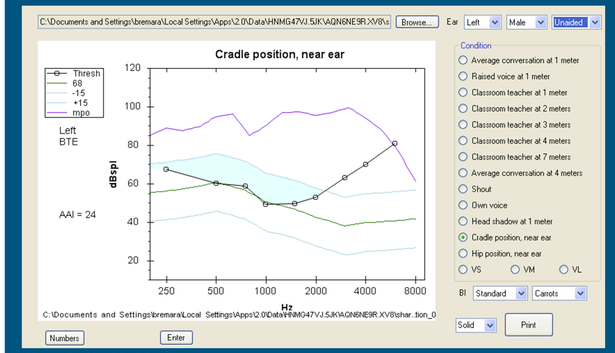

Figure 3: Unaided Cradle

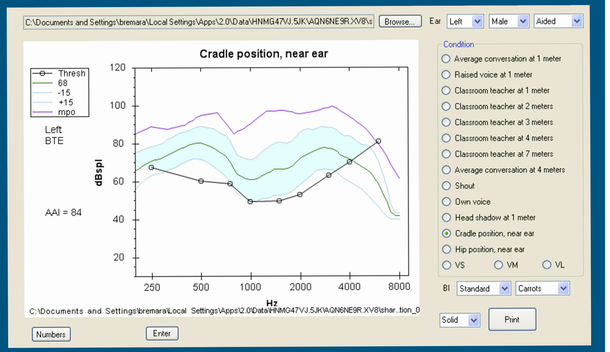

Figure 4: Aided Cradle

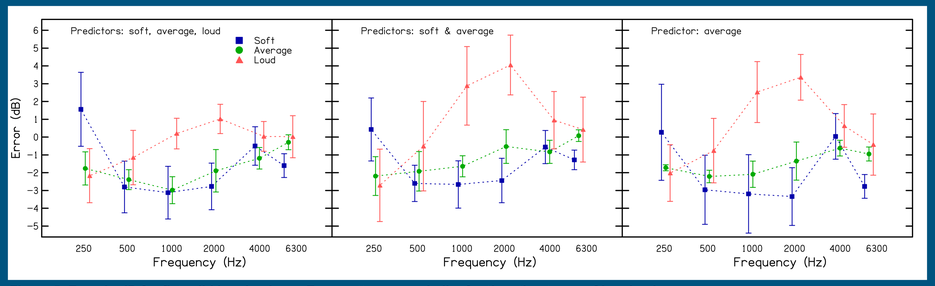

Figure 5. Error in dB for flat-mild hearing loss. Error pattern was similar for the other types of hearing loss.

VALIDATION

Method

To assess the validity of the SHARP estimated output levels we:
- Tested three hypothetical audiograms (flat-mild, flat-moderate, reverse slope).
- Collected data from the following hearing aids: Siemens Explorer 500P, Resound Alera, Oticon Agil, Sonic Innovations Velocity 6, Phonak Naida V SP, Oticon Safari P 900, and Unitron 360+, and Starkey X110.
  - turned off all advance processing (feedback control, noise reduction, directional microphones, etc).
- Programed each hearing aid
  - to DSL pediatric (Scollie et al 2005) targets using average RECD values for a 12 year old.
- Completed verification using the Verifit.
  - matched output to within 5 dB for soft (55 dB SPL), average (65 dB SPL) and MPO.
  - measured output for loud (75 dB SPL) speech.
- Imported the data into SHARP and predicted output for soft, average and loud speech.
- Varied the number of input levels used in the prediction to determine the minimal set of input levels required for accurate prediction.
- Computed the mean and standard deviation of the dB error (predicted output - measured output).

Results

See Figure 5. Two trends are observable. First, mean errors were less than 5 dB. Second, the size of the error decreased as the number of input levels used to predict the output increased.

CONCLUSION

- Listeners with hearing loss experience a variety of speech-input levels.
- SHARP allows you to compare audibility with and without amplification across different of listening situations.
- Modifications to SHARP allow for importation of real-ear data and accurate predictions of hearing-aid output.

FUTURE DIRECTION

- Incorporate frequency lowering
  - Nonlinear frequency compression
  - Frequency transposition
- Modify SII to account for:
  - Frequency lowering
  - Reverberation
- Validate using advanced signal processing

ACKNOWLEDGEMENTS

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REFERENCES

- ANSI (1997). American national standard methods for calculation of the speech intelligibility index. (ANSI S3.5-1997).
- Scollie, S., Seewald, R., Cornelisse, L., Moodie, S., Bagatto, M., Launagaray, D., Beaulac, S., & Pumford, J. (2005). The Desired Sensation Level multistage input/output algorithm. Trends in Amplification, 9(4), 159-197.

For more information and to obtain a copy of SHARP;