Vol. 3 No. 4 / 2000

SONIC innovations

Evaluation of NAL-NL1 Using the NATURA™ DSP Hearing Aid

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Abstract

The National Acoustic Laboratories released a new nonlinear fitting algorithmthat adjusts pure-tone gain targets based on the number of compression channels inthe hearing aid. This informational paper compares hearing aid fittings using the NAL-NL1 procedure to the proprietary fitting algorithm for the 9-channel DSP NATURA and CONFORMA™ hearing aids with the dedicated EXPRESSfit™ software. Comparisons between the recommended frequency responses with respect to number of compression channels will be discussed.

Presented at the American Academy of Audiology 12th Annual Convention on March 16–19, 2000, in Chicago, Illinois.

INTRODUCTION

The new NL1 fitting algorithm from the National Acoustic Laboratories (NAL) prescribes level-dependent frequency response curves suitable for programming multi-channel hearing aids.1 A previous evaluation of the NAL-NL1 prescription (version 1.1), as compared to the EXPRESSfit fitting algorithm for NATURA, revealed that both algorithms showed similar frequency response shaping for gain and output, but the NAL-NL1 algorithm recommended more gain, higher WDRC kneepoints, and greater compression ratios than EXPRESSfit.2 This paper uses multiple audiograms, as recommended by Byrne, et al.,3 to systematically investigate the two algorithms using the newer NAL-NL1 version 1.2 software.4 Four sample audiograms representing different hearing loss configurations are shown in Figure 1.

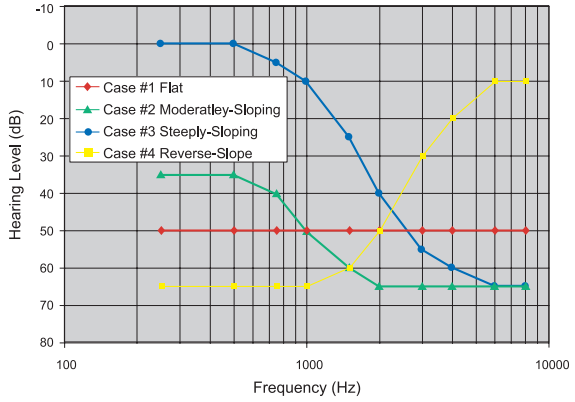


Figure 1. Sample Audiograms

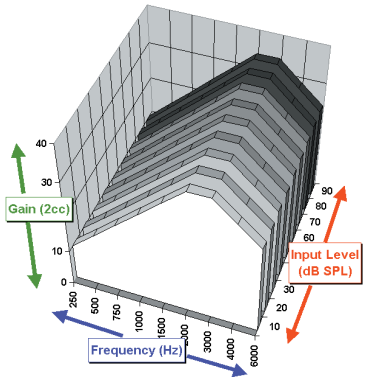


Figure 2.
3-D Discrete Display

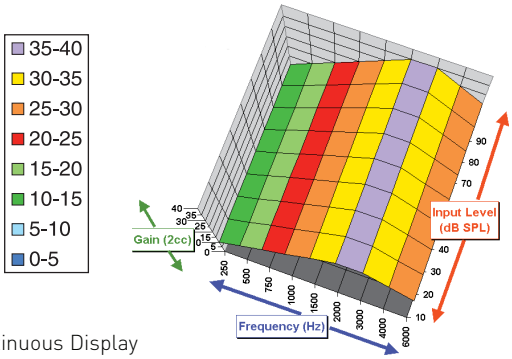


Figure 3.
3-D Continuous Display

This evaluation of fitting algorithms uses a three-dimensional (3-D) graphing technique that allows the non-linearities in frequency, input intensity, and prescribed gain to be visualized more easily, as shown in figures 2 and 3.

Figure 2 graphs in 3-D a typical hearing aid fitting with high-frequency emphasis where the frequency response curve does not change with respect to input level; i.e., is linear. Figure 3 graphs the same fitting in 3-D, using a topographical format. The high-frequency emphasis is shown with the changing color bars with respect to frequency (the x-axis) and the linearity is shown by the lack of change in the color bars with respect to input level (the y-axis).

CASE #1: FLAT AUDIOGRAM

For the moderate, flat audiogram, figures 4 and 5 show the recommended frequency response curves from the two algorithms. Figures 6 and 7 show the two corresponding continuous functions. These graphs illustrate a difference between the two algorithms for low input levels (< 50 dB SPL). Notice that the NAL-NL1 algorithm recommends frequency responses that are unchanging at these levels. In

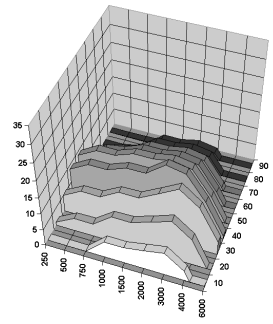


Figure 4. NATURA Fitting

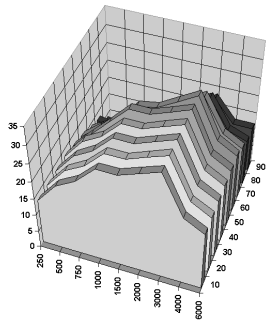


Figure 5. NAL-NL1 Fitting

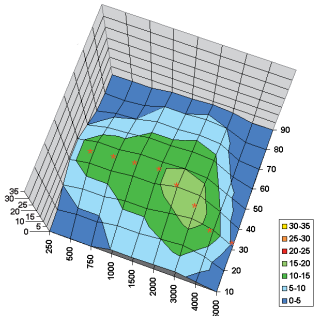


Figure 6. NATURA Fitting

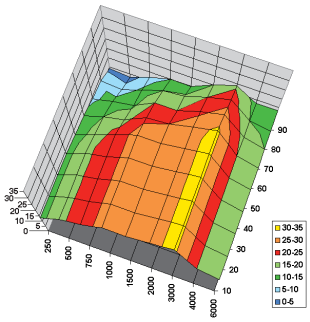


Figure 7. NAL-NL1 Fitting

contrast, the EXPRESSfit algorithm prescribes responses that vary with input level for low intensities. The difference is that the EXPRESSfit algorithm uses expansion, whereby gain decreases as input level decreases. (Expansion is the functional reciprocal of compression.)

CASE #2: MODERATELY-SLOPING AUDIOGRAM

Figures 8, 9, 10, and 11 show the recommended responses for the moderately-sloping audiogram. These graphs illustrate another difference between the two algorithms. Both recommend mild high-frequency emphasis, as would be expected for a moderately-sloping audiogram. However, the NAL-NL1 fitting recommends slightly more gain than the EXPRESSfit fitting. The higher gain in the NAL-NL1 approach is delivered along with higher outputs in the region of hearing loss.

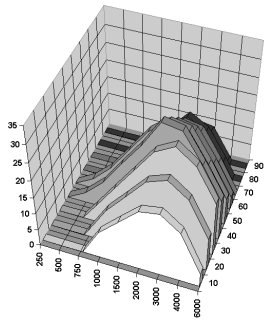


Figure 8. NATURA Fitting

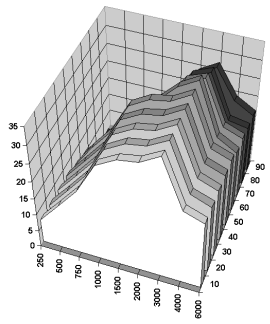


Figure 9. NAL-NL1 Fitting

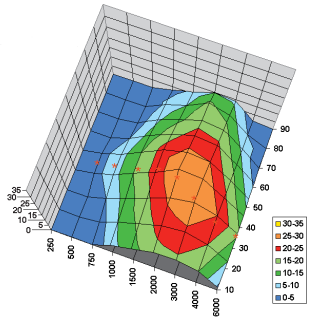


Figure 10. NATURA Fitting

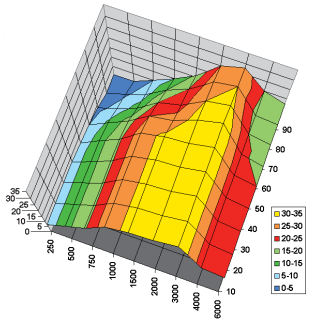


Figure 11. NAL-NL1 Fitting

CASE #3: STEEPLY-SLOPING AUDIOGRAM

For the steeply-sloping audiogram, the recommended hearing aid fittings are shown in figures 12–15. These graphs reveal a third difference between the two algorithms. In this example, the recommended gain is greatest at the frequencies of greatest hearing loss, 3000–4000 Hz for the input levels of 30–40 dB SPL (the zone for soft, high-frequency speech cues). Above this intensity level, both algorithms roll off gain using WDRC, and below this level the EXPRESSfit fitting rolls off gain using expansion. However, a major difference is the NAL-NL1 fitting recommends significantly greater gain in the mid frequencies, from 1000–2000 Hz, than the EXPRESSfit algorithm.

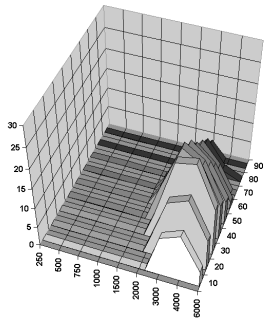


Figure 12. NATURA Fitting

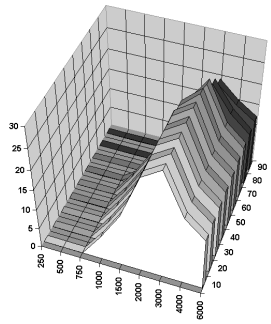


Figure 13. NAL-NL1 Fitting

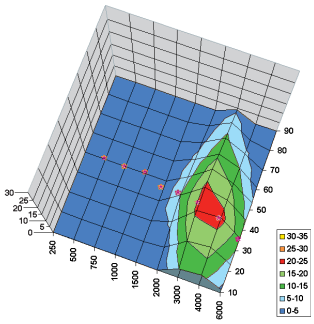


Figure 14. NATURA Fitting

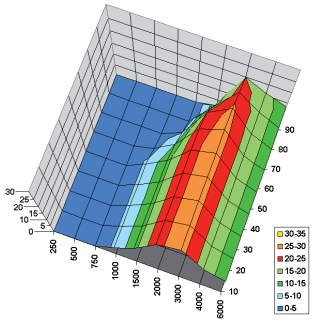


Figure 15. NAL-NL1 Fitting

CASE #4: REVERSE-SLOPE AUDIOGRAM

Figures 16–19 have the recommended responses for a reverse-slope audiogram representing a moderate, low-frequency hearing loss. Notice that for both fittings, the frequency response is static with respect to low input levels. For cases with moderate or severe low-frequency losses, the EXPRESSfit algorithm automatically selects the "no Expansion" option and the gain function is linear below the 40 dB compression kneepoints.

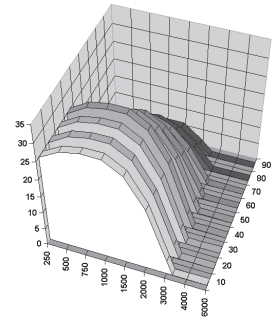


Figure 16. NATURA Fitting

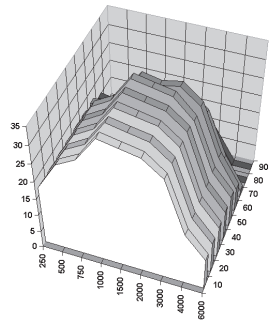
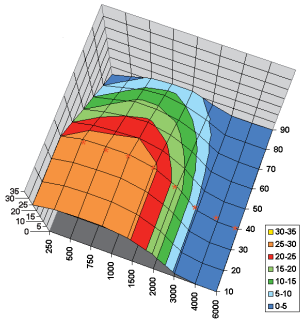
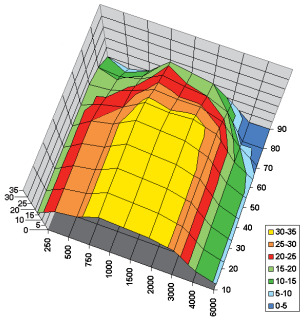


Figure 17. NAL-NL1 Fitting





RESULTS

Similarities: Both the NAL-NL1 and the EXPRESSfit prescriptive algorithms recommend frequency shaping appropriate to the audiogram shape, gain and compression ratios commensurate with the degree of hearing loss, with wide dynamic range compression (WDRC), or level-dependent gain, for moderate and high input levels.

Differences: The two algorithms differ in several "speech-weighted expansion," with level-dependent gain, for low input levels whereas the NAL-NL1 algorithm is linear for these inputs. Second, the EXPRESSfit algorithm recommends less gain and lower outputs than the NAL-NL1 algorithm. Third, the EXPRESSfit algorithm recommends gain in frequency regions directly tied to the regions of hearing loss, whereas the NAL-NL1 algorithm generally recommends gain over a bandwidth that is somewhat wider than the region of loss.

The differences between the two algorithms are by design. For low and moderate intensity levels, the NAL-NL1 algorithm utilizes frequency response shaping that maximizes the audibility for conversational speech levels. In contrast, the EXPRESSfit fitting algorithm utilizes expansion shaped to the long-term-average speech spectrum to maximize the audibility of soft speech, coupled with milder gain and milder output levels to promote listening comfort of more intense speech and environmental sounds.

CONCLUSIONS

The prior large differences between the NAL-NL1 and the EXPRESSfit algorithms have been reduced with the development of version 1.2 software, however some significant differences still remain. Adding a 9-channel option to the NAL-NL1 algorithm should further decrease the differences.

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1. NAL Non-Linear NAL-NL1 User Manual (1999). National Acoustic Laboratories, Chatswood, NSW, Australia.
2. Bray & Nilsson (1999). Comparison of two non-linear, multi-channel fitting algorithms. NAL Conference - Hearing Aid Amplification for the New Millennium, Sydney, Australia.
3. Bryne, Dillon, Ching, Katsch, & Keidser (1999). The NAL-NL1 nonlinear hearing aid selection procedure: Prescriptions and comparisons with other procedures. NAL Conference - Hearing Aid Amplification for the New Millennium, Sydney, Australia.
4. Dillon (2000). Personal communication.

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