



# The Evolution of Multi-channel Compression Hearing Aids

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## ABSTRACT

Advanced digital signal processing is becoming the standard for new hearing aid models, but the signal processing algorithms are not static, and improvements in basic functioning are being introduced as well. A nine-channel signal-processing algorithm has recently been updated to improve noise, distortion, as well as device utility. Data are presented demonstrating improvements in subjective ratings and performance measures between the original form of the signal processor and the revised version.

# INTRODUCTION

Expectations for new DSP-based hearing aid systems are for novel signal processing strategies, but even basic signal processing properties can be improved. Signal quality can be improved with changes to basic components of the circuit, including analog-to-digital convertors, circuit layouts, digital-to-analog convertors, and the implementation of these designs in silicon. As an example of the types of improvements possible in core signal processing abilities, the second generation of the 9-channel DSP hearing aid system used in the ALTAIR™ hearing aid was compared to the original form of this system used in the NATURA™1.

# METHOD

**Subjects:** Thirty subjects (ten wearing each style) were fit binaurally with CIC, ITC, or ITE ALTAIR devices to match the configuration of their previously-worn NATURA devices. All subjects were diagnosed with symmetrical, bilateral, sensorineural hearing loss. Mean audiograms by device style are displayed in Figure 1.

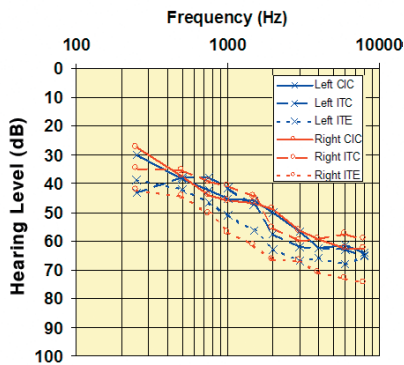


Figure 1: Group audiograms by device style

**Fittings:** Hearing aid fittings are defined as coupler output for 50 and 90 dB inputs at 9 frequencies. Figure 2 compares fitting targets for both sets of devices (grouped by device style).

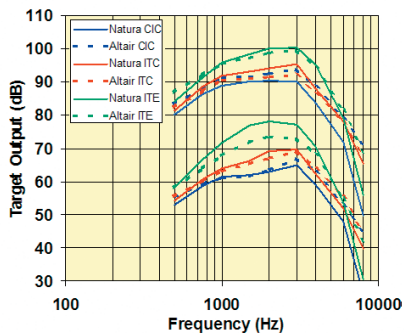


Figure 2: Targets for Natura and Altair devices

**Apparatus:** Subjects were fit using the EXPRESSfit™ fitting algorithm developed for this 9-channel system. The algorithm maps the dynamic range of normal hearing into the dynamic range of the subject in 9 independent, half-octave channels.

**Fittings:** Hearing aid fittings are defined as coupler output for 50 and 90 dB inputs at 9 frequencies. Figure 2 compares fitting targets for both sets of devices (grouped by device style).

The fitting targets were similar for the NATURA and ALTAIR fittings except for the ITE group, with higher “soft” targets for the NATURA devices than for the new devices. The high frequencies in ALTAIR are set to match the measured roll off of the transducers, while

the NATURA targets were not. This explains the steeper roll-off, especially for the 90 dB curves.

# RESULTS

**Functional Gain:** Soundfield thresholds were measured using warble tones with and without hearing aids. The difference in thresholds is the functional gain provided by the hearing aids. Figure 3 displays the gain grouped by device style for the NATURA and ALTAIR devices. Gain is greatest for the ITE group who had the greatest hearing loss. Gain is the least for the CIC group. Overall, there were no significant differences in functional gain between NATURA and ALTAIR conditions.

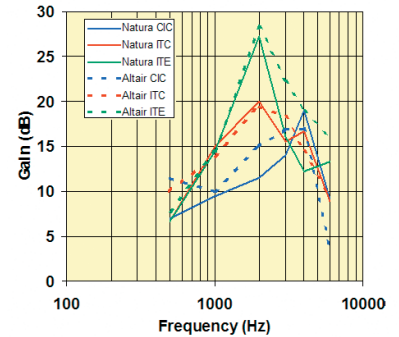


Figure 3: Functional gain grouped by device style for the NATURA and ALTAIR devices. Gain is greatest for the ITE group who had the greatest hearing loss. Gain is the least for the CIC group. Overall, there were no significant differences in functional gain between NATURA and ALTAIR conditions.

**Sound Quality Ratings:** Subjects were asked to rate the sound quality of four types of stimuli: the subject’s own voice, music, some recorded speech (in quiet and noise), and a series of environmental sounds (such as birds

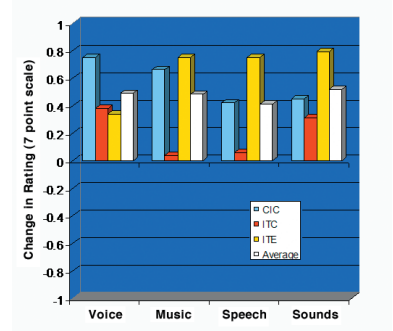


Figure 4: Mean ratings for the two chips and crickets, automobiles, pots and pans, etc). Ratings were made on a 7-point scale for Naturalness, Clarity, Ease of understanding, and Overall Sound Quality. Average ratings grouped by device style for NATURA devices were subtracted from rating for ALTAIR devices. The change in ratings is displayed in Figure 4, with a positive value demonstrating a higher rating for the new devices. Analysis of Variance found a main effect of model (NATURA vs. ALTAIR) with higher ratings for ALTAIR ( $p < .05$ ).

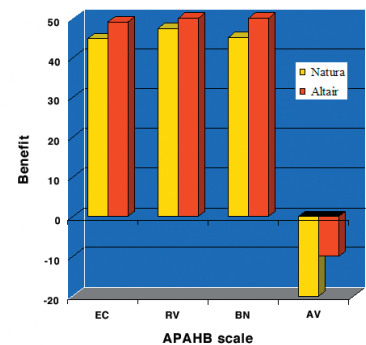


Figure 5: APAHB scores comparing devices with higher ratings for ALTAIR ( $p < .05$ ).

APHAB2: Questionnaires were given to subjects at the beginning of the project to evaluate their then-current devices (NATURA), and after completion of the project on the new devices (ALTAIR). Benefit scores (relative to unaided) are displayed in Figure 5. Subjects consistently preferred the new devices on all scales ( $p < .05$ ).

HINT3: Reception Thresholds for Sentences (RTS) were measured in quiet and noise. The RTS indicates the presentation level of the speech materials at which the subject can repeat the materials correctly half the time. A lower RTS corresponds to better performance. Figure 6 displays thresholds in quiet and noise for each device style and overall. Analysis of Variance found a significant effect of model, with improved performance with ALTAIR ( $p < .05$ ).

## DISCUSSION

The DSP component of a 9-channel hearing system was revised with the objective of reducing noise and distortion, while improving device utility. In order to evaluate the implications of this update on clinical performance, a group of 30 subjects already wearing the first generation of the system were fit with new devices utilizing the new circuit. The original model is labeled NATURA and the new model is labeled ALTAIR. Sound quality ratings, APHAB scores, and HINT thresholds all found significant improvements with the

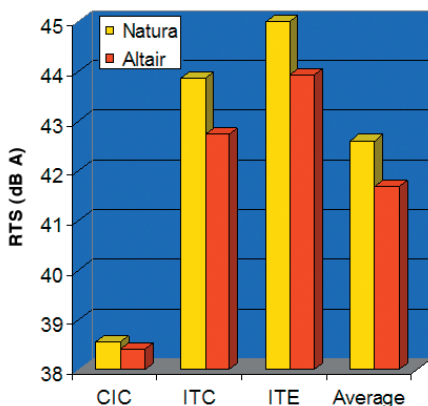


Figure 6: HINT RTS for Quiet and Noise conditions

ALTAIR devices. These devices did not implement additional signal processing features, but included revised processes to improve the core signal processing platform. The new devices did include tonal signals to indicate memory changes and end of battery life, which were not available in NATURA. This addition is expected to impact some of the subjective rating data. Even with this additional feature, noticeable differences were found without dramatic changes to the amount of amplification (as seen in the fitting targets and functional

gain data). The differences cannot be attributed to audibility, but instead to the improvements in the underlying signal processing of the new product.

## REFERENCES

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