ReSound hearing aids add fitting flexibility

Jennifer Groth, MA; Isabel Schindwolf, MsC; Tao Cui, AuD

ABSTRACT

ReSound hearing aids are known for their natural, clear sound quality, which is a consequence of following the Organic Hearing philosophy. Although many users prefer and thrive with a default ReSound fitting to Audiogram+, some Hearing Care Professionals (HCPs) prefer to fit to other gain prescriptions. In this paper, we show how beginning with the ReSound OMNIA, accuracy of first-fit target match to NAL-NL2 is optimized to assist HCPs in easily achieving their desired fitting.

The Organic Hearing philosophy that guides the development of ReSound hearing solutions aims to provide experiences that allow people to hear naturally, feel natural and connect naturally with the world around them. One of the ways ReSound hearing aids help people to hear as naturally as possible is how the compression system pairs with other signal processing to enhance the user's listening experience.

The ReSound compression system was originally designed to mimic the compressive nonlinearity of the cochlea that is lost when outer hair cell damage has occurred[1] and was fit using a loudness scaling procedure.[2] To simplify fitting, a threshold-based gain prescription, Audiogram+, was empirically formulated based on many loudness scalings. Audiogram+ prescribed gains for narrowband input levels of 50 and 80 dB SPL in order to control the compression ratio in each frequency band. While the ReSound compressor originally consisted of 2 bands, the band structure became more complex as technology advanced. Therefore, Audiogram+ targets were revised to account for the effects of updated multi-band structures.

Today, the ReSound compressor consists of 17 highly overlapping bands that yield a non-uniform band structure similar to a model of the critical bands in the cochlea. The band center frequencies are separated by approximately 1.3 Bark scale units. The gain-frequency response is effectively controlled by a smaller number of gain "handles" depending on the input bandwidth and technology level of the specific product.

Because natural sound is a priority, the compression parameters have evolved to minimize the inevitable signal distortions that can occur, while still improving hearing-related benefit:

- Default attack and release times for compression are 12ms/70ms which is more conservative than early versions of the ReSound compressor.
- Variations on slower time constant schemes are offered as choices in the fitting software to preserve signal dynamics when listening to music or for other specific listening scenarios.
- An adaptive attack time that depends on the degree of level change in the input also adds to sound quality by preventing fluttering or pumping artifacts in environments with little variation in input level, such as when the user is in quiet.[3]
- The maximum compression ratio has a limitation of 3:1. The rationale for this limitation is to preserve sound quality, as large compression ratios combined with fast time constants may lead to excessive distortion.
- Low compression kneepoints are set to 50 dB SPL. Like the small changes to the time constants, the increase in the low compression kneepoints compared to early ReSound hearing aids can be expected to improve sound quality without significant impact to speech understanding and benefit for post-lingually deafened adults. In addition, likelihood of feedback

in quiet environments may be reduced.

- A mid-level kneepoint at 65 dB SPL was added to better enable fit to third party prescriptive targets. Audiogram+ does not use this kneepoint in the prescription. Thus, the compression ratios above and below 65 dB SPL are the same when fitting to Audiogram+.

- Output limiting kneepoints: these are set in accordance with the NAL-NL2 prescription for maximum output.

- Expansion kneepoints are device specific. This allows inherently quieter hardware platforms to have lower expansion kneepoints than noisier platforms, thereby optimizing the input range over which maximum gain can be applied.

As the ReSound compression system has advanced, a unique sound profile has also emerged. ReSound hearing aids are often described as having a crisp and clear sound. While the sound quality of ReSound hearing aids may be appreciated and even preferred by many hearing aid users, the current characteristics can pose a challenge when HCPs try to fit the system to third party targets that are based on broadband speech-weighted input, most notably NAL-NL2.[4] While the prescribed gain-frequency response can be adequately met for moderate input targets, the prescribed compression ratios may not be achievable. As demonstrated in a study on the performance of automated real ear measurement,[5] prescribed gains for 65 dB SPL targets can be met, while gains for 50 dB SPL targets can undershoot in the high frequencies, and gains for 80 dB SPL targets may overshoot, particularly in the mid frequencies. The compression kneepoints at 50 dB SPL and the compression ratio limitation of 3:1 contribute to these findings. As a result of this fitting experience, some HCPs who prefer to fit to NAL-NL2 do not select ReSound hearing aids for their patients.

Beginning with ReSound OMNIA, compression characteristics are automatically selected to accommodate the chosen fitting prescription. This means that HCPs and hearing aid users who prefer the organic sound provided by ReSound hearing aids will continue to have this experience, while those who prefer fitting to NAL-NL2 will be able to meet targets for soft, moderate and loud input levels. The following measurements demonstrate how the first fit to NAL-NL2 has been improved in ReSound OMNIA compared to ReSound ONE.

Coupler measurements were carried out based on fittings of the N3, S2 and N5 standard audiograms[6] (see Table 1). For each test, a pair of ReSound OMNIA RU962 DRW instruments with MP (for audiograms N3 and S2) or HP (for audiogram N5) receivers were programmed to the NAL-NL2 fitting rule in ReSound Smart Fit fitting software. The hearing instrument 2cc coupler gain was then measured in an Aurical HIT testbox with a 30-second long ISTS[7] signal at levels of 50, 65, and 80 dB SPL. The NAL-NL2 parameters were set as shown in Table 2. The same procedure was used to measure ReSound ONE RT962 DRW hearing aids.
As seen in Figures 1,2 and 3, the modifications made in the ReSound OMNIA hearing aid improves the match to NAL-NL2 speech targets compared to ReSound ONE.

	250 Hz	500 Hz	750 Hz	1k Hz	1.5kHz	2kHz	3kHz	4k Hz	6k Hz
S2	20	20	23	25	30	35	40	45	50
N2	35	35	35	40	45	50	55	60	65
N3	55	55	55	55	60	65	70	75	80
N5	80	85	87.5	90	90	90	95	100	100

Table 1. Standard audiograms used for fitting and measurement. The values in the cells are dB HL.

NAL-N2 parameter	Setting
Gender	Unknown
Date of birth	01-01-1990
Transducer	Supra-aural headphone
Number of hearing aids	Bilateral
Tubing	RITC
Compression channels	17
Limiting	Wideband
Wideband compression threshold	50

Table 2. Selected NAL-NL2 parameters

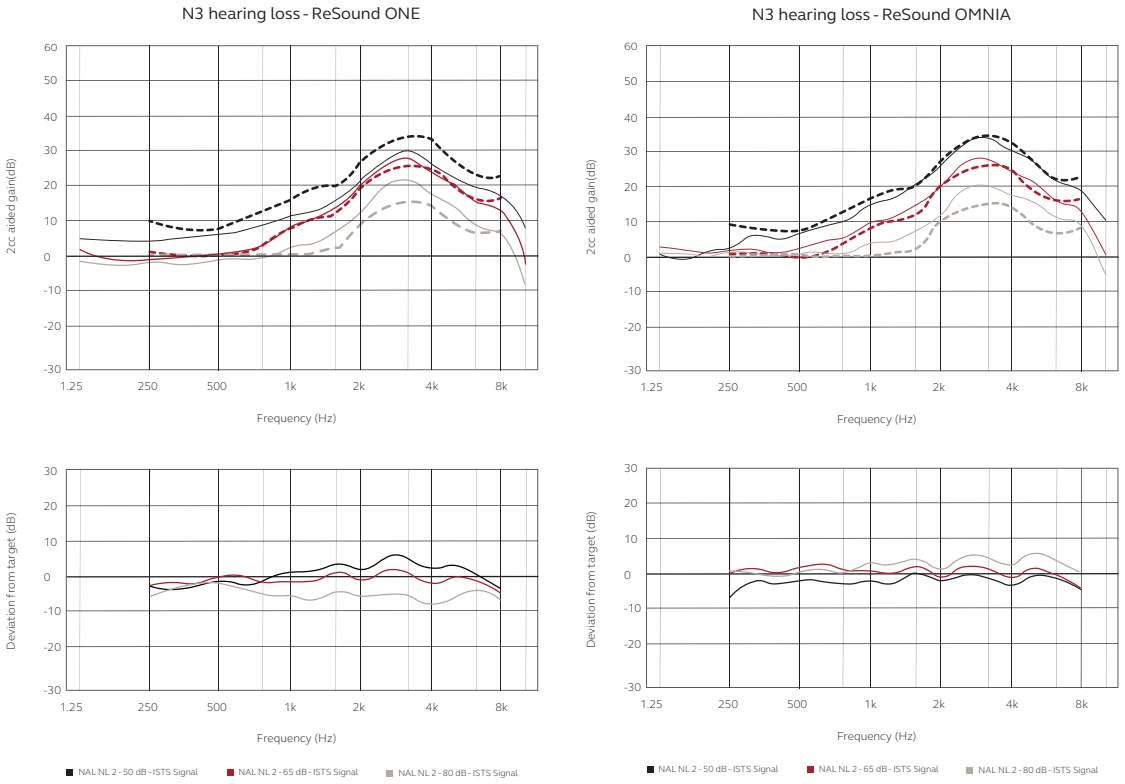

Figure 1: Comparison of 2cc coupler measurements of ReSound ONE (left panel) and ReSound OMNIA (right panel) hearing aids fit to the N3 audiogram using NAL-NL2. Dashed lines are target curves and solid lines are measurements.

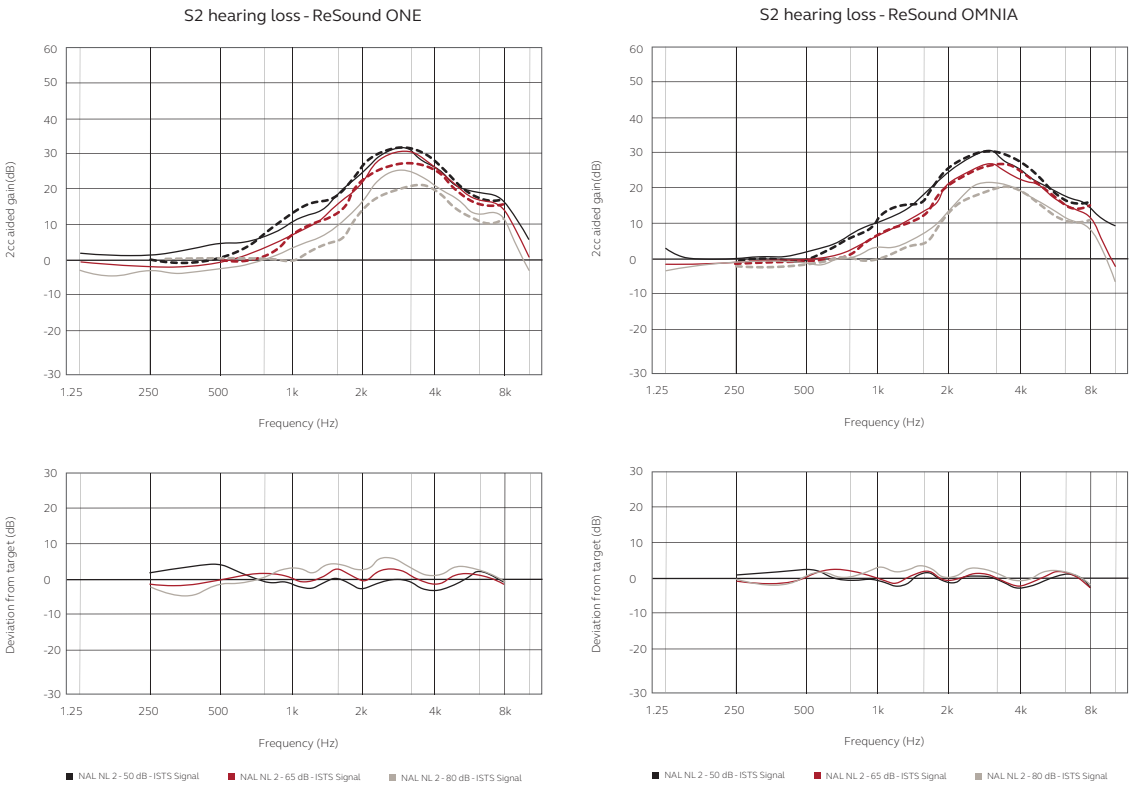

Figure 2: Comparison of 2cc coupler measurements of ReSound ONE (left panel) and ReSound OMNIA (right panel) hearing aids fit to the S2 audiogram using NAL-NL2. Dashed lines are target curves and solid lines are measurements.

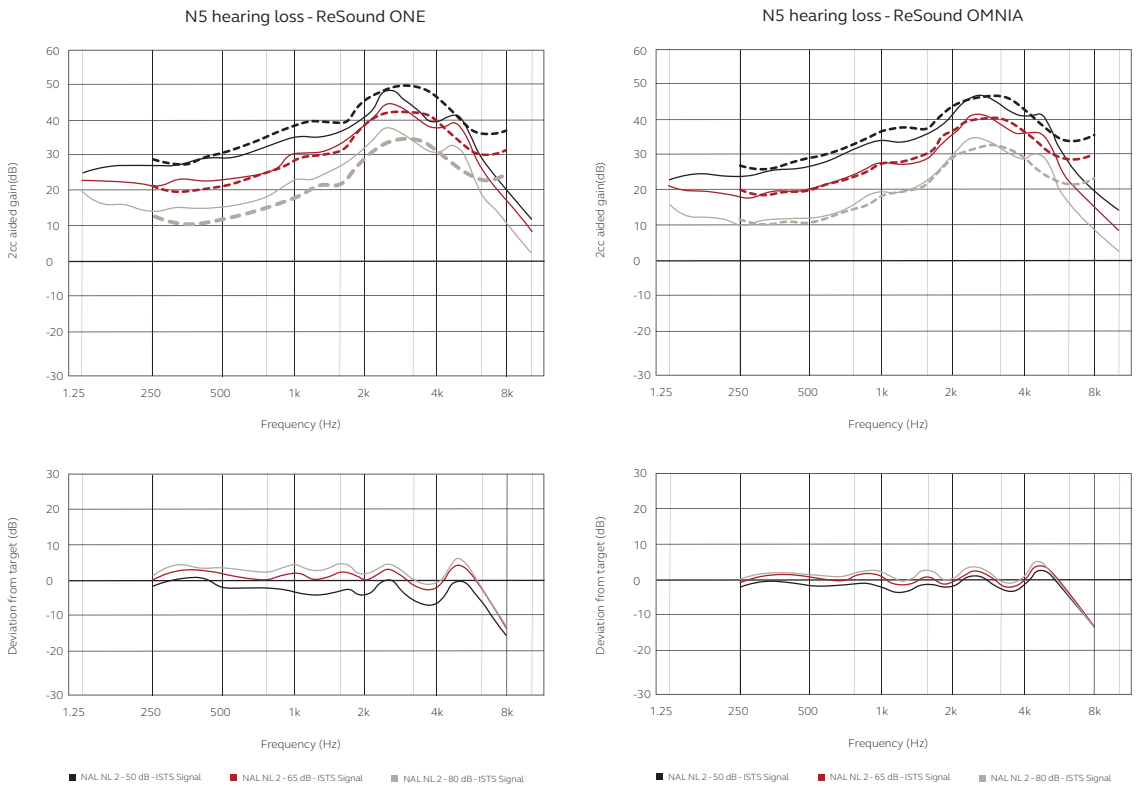

Figure 3: Comparison of 2cc coupler measurements of ReSound ONE (left panel) and ReSound OMNIA (right panel) hearing aids fit to the N5 audiogram using NAL-NL2. Dashed lines are target curves and solid lines are measurements.

Real-ear measurements were also performed on ten ears of five adult volunteers with normal hearing where the first fit to NAL-NL2 with ReSound OMNIA RU961 DRW instruments with MP receivers was verified using the N2 audiogram. Measurements were made using a 30-second sample of the ISTS signal at input levels of 50, 65 and 80 dB SPL. As a benchmark, the same measurements were performed using a pair of ReSound ONE RT961 DRW instruments with MP receivers. Figure 4 shows the average deviations from NAL-NL2 targets for each device at each input level. The average target match is improved at all three input levels with the ReSound OMNIA compared to the ReSound ONE.

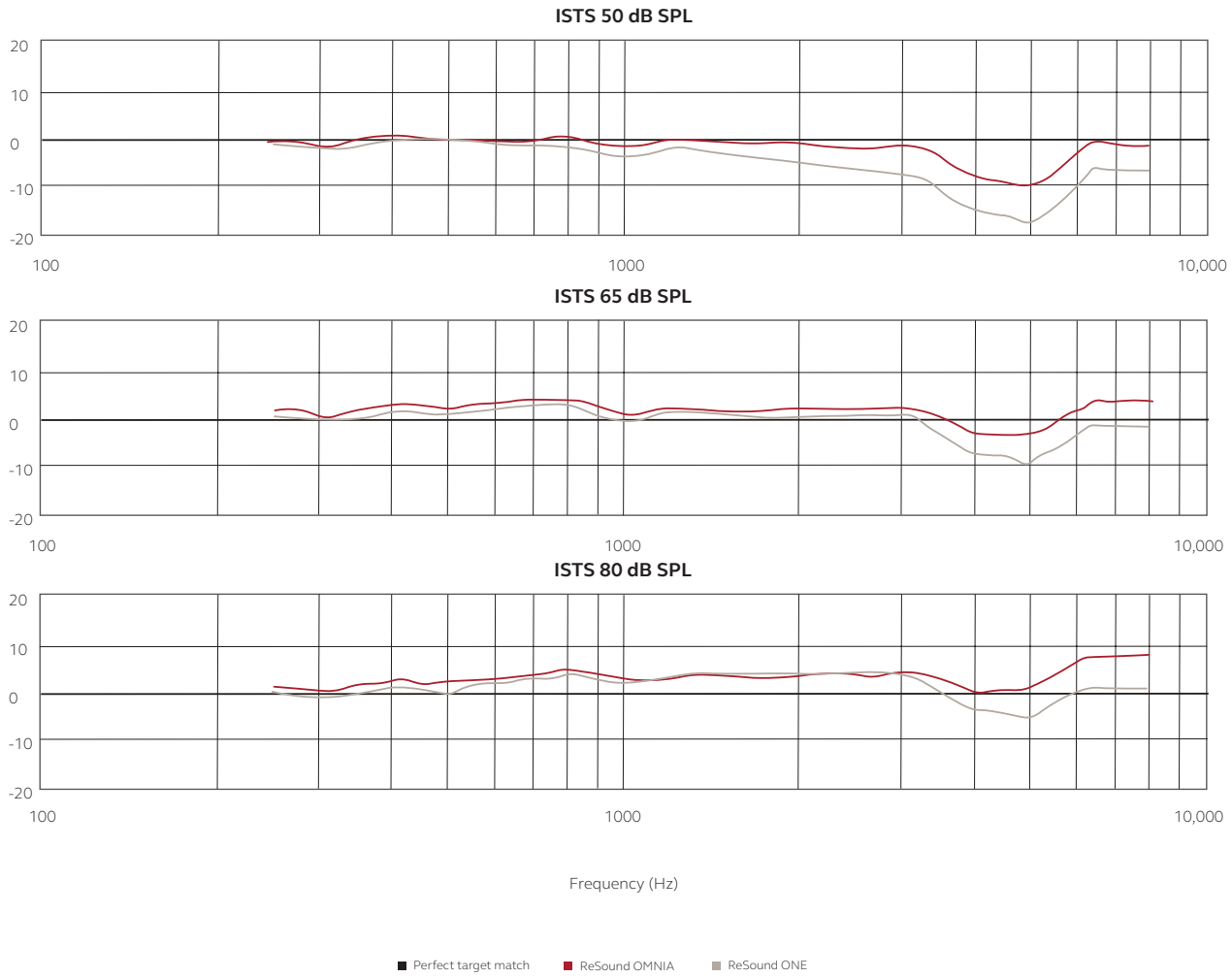

Figure 4. Deviation of mean REIG from NAL-NL2 REIG speech targets for three input levels of the ISTS signal. The solid line at 0 dB is an ideal target match, the red line is ReSound OMNIA, and the grey line is ReSound ONE.

CONCLUSION

ReSound hearing aids were designed along with the Audiogram+ fitting rationale according to the Organic Hearing philosophy to allow users to hear and use their hearing as naturally as possible. This design did not allow enough flexibility for HCPs who wished to fit to the NAL-NL2 fitting rationale to accurately match targets. Beginning with ReSound OMNIA, compression characteristics are automatically optimized to provide an accurate first fit to NAL-NL2 if this prescription is selected in Smart Fit by the HCP. Both 2cc coupler and real ear measurements demonstrate that this approach provides accurate fitting to NAL-NL2 targets.

References

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Manufacturer according to FDA:

GN ReSound North America
8001 E. Bloomington Freeway
Bloomington, MN 55420
USA
1-800-248-4327
pro.resound.com

ReSound Government Services
8001 E. Bloomington Freeway
Bloomington, MN 55420
USA
1-800-392-9932
gs.resound.com

Manufacturer according to Health Canada:

ReSound Canada
2 East Beaver Creek Road, Building 3
Richmond Hill, ON L4B 2N3
Canada
1-888-737-6863
pro.resound.com

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