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Comparison of Generic Prescriptive Targets Between Hearing Aid Manufacturers and a Real-Ear Analyzer

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Abstract

Prescriptive approaches are typically implemented for estimating the optimal gain and output during an initial hearing aid fitting. In this study, simulated real ear aided responses (REAR) were compared for hearing aids from different manufacturers and compared to targets for different prescriptive methods. The findings from the present study indicated that for the same generic prescriptive method and the same degree of hearing loss, the targets varied up to 26 dB between hearing aid manufacturers and the real-ear analyzer, when all parameters were held constant.

Introduction

Prescriptive approaches are typically implemented for estimating optimal gain and output during an initial hearing aid fit. There are two main generic prescriptive approaches utilized - National Acoustics Laboratory Non-Linear Version 1 and Version 2 (NAL-NL1 and NAL-NL2), as well as Desired Sensation Level (DSL). NAL algorithms are based on maximizing speech intelligibility at the listening level preferred by the patient. It is assumed intelligibility has been achieved when all bands of speech are perceived as having the same loudness. In other words, NAL utilizes the loudness equalization rationale, aiming to equalize the perception of loudness over a range of frequencies. On the other hand, DSL uses the loudness normalization rationale, meaning it intends to restore loudness perception for specific frequencies to that of a listener with normal hearing (Johnson and Mueller, 2012). DSL aims to provide an audible and comfortable signal to the patient in all frequency regions (Dillon, 2012). Consequently, DSL and NAL formulas result in varying frequency response curves, insertion gain, and compression parameters. For example, for a flat hearing loss, the early version of the DSL (v4.1) algorithm prescribes more low frequency gain, while NAL-NL1 constrains overall loudness to the range, as heard by normal hearing individuals (Ching, Scollie, Dillon, Seewalk, Britton, & Steinberg, 2009). In addition to these two, there are other generic prescriptive approaches. For example, Camfit, developed at the University of Cambridge in England, follows the general idea of providing a specific loudness pattern over the frequency range for speech. CAMEQ2-HF (Cambridge method for loudness equalization 2-high-frequency) is the most commonly used revision of this formula.

It is well known the amount of prescribed gain may vary from different manufacturers for the same degree of hearing loss, depending on multiple factors, including hearing aid experience, gender, type of hearing aid, size of venting, and the selected prescriptive method. It is agreed among clinicians and manufacturers that NAL and DSL prescriptions are a good place to begin for a hearing aid fit (Mueller, Ricketts, & Bentler, 2016). Both prescriptive methods result in similar speech intelligibility and loudness values, yet may provide different insertion gain (Johnson & Dillon, 2011)**.** NAL-NL2 is the most recent and more commonly used of the NAL formulas. DSL v5 is the newest algorithm of DSL, and according to Johnson (2013), provides more insertion gain than NAL prescription, providing more amplification for those with severe to profound hearing losses. DSL child is best used with pediatric patients, as it prescribes a value for real-ear aided gain rather than real-ear insertion gain, using patient-preferred sensation levels to calculate the target aided gain (Dillon, 2012; Johnson, 2013). The two formulas provide similar results for overall loudness and speech intelligibility in quiet and noise. The differences between the two occur at frequencies that are not critical to amplification, or are unable to be amplified to the level necessary for the hearing loss (Mueller, Ricketts, & Bentler, 2016).

Recent research has begun to explore the effects of prescriptive approach, and different versions of each approach, on prescribed gain. Johnson and Dillon (2011) compared and contrasted similarities and differences between generic prescriptive formulas. Results from their study indicated that DSL m[i/o] and NAL-NL2 provided less overall loudness while NAL-NL1 provided greater overall loudness. For speech intelligibility in quiet, no significant differences between predicted speech intelligibility index (SII) for DSL m[i/o], NAL-NL1, and NAL-NL2. It appeared that DSL m[i/o] and NAL-NL2 both prescribed insertion gain that resulted in loudness that was preferred by typical hearing aid users to both NAL-NL1 and CAMEQ2-HF, while continuing to provide comparable speech intelligibility in both quiet and noise to NAL-NL1 and CAMEQ2-HF. In another study, the differences between the NAL-NL2 and CAM2 prescriptive method with adult participants were investigated (Johnson, 2013). Results revealed NAL-NL2 prescribed little to no audibility as the hearing loss became more severe, based on assumed desensitization, or reduced usability of the remaining hearing. CAM2 attempted to restore audibility, regardless of hearing loss severity. Both prescriptive approaches tended to offer greater amplification for improved comfort for higher inputs of stimuli, but their algorithms varied.

While generic fitting formulas were developed based on research not related to a specific manufacturer, proprietary formulas are created and researched by manufacturers (Keidser, Brew, & Peck, 2003). Because proprietary formulas are created by manufacturers, information and explanation of fitting targets, differences between hearing losses, and comparisons with other algorithms may not be available publicly or published in peer-reviewed sources. Keidser et al. (2003) found overall gain varied by approximately 10 dB across all configurations of hearing loss examined, as well as across the four manufacturer's proprietary prescriptive formulas, which was considered clinically significant. According to Johnson and Mueller (2016), differences between values of output at each selected frequency were considered clinically significant (greater than +/- 5 dB). Results showed a distinct difference in the frequency responses between fitting formulas for severe hearing loss at frequencies lower than 1000 Hz. This was due to differences between normalizing loudness and maximizing speech intelligibility. Data suggested targets prescribed by different fitting formulas could drastically change amplification characteristics for individuals with similar hearing losses (Keidser et al., 2003).

Moreover, more manufacturers have started to incorporate their own integrated real-ear measurement systems in their fitting software, including ReSound (AutoREM), Widex (Sensogram), and Phonak (TargetMatch). Targets used in these real-ear analyzers may be different when compared to prescriptive targets from first-fit manufacturers' fitting software, as well as an independent real-ear analyzer. Caution should be utilized when using the manufacturer's own integrated REM systems, until they have been independently validated. In a study conducted by Warman (2014), two different receiver-in-the-ear hearing aids within the same hearing aid manufacturer were utilized with the Frye Fonix 8000 Hearing Aid Test System to evaluation real-ear measurements. This study found that a simulated real-ear measurement system within the manufacturer software was not sufficient for fitting hearing aids. Due to potential differences between prescribed targets and measured responses, it is possible to "under-fit" or "over-fit" a patient, resulting in poorer patient satisfaction and benefit. Therefore, verification using real-ear measurements are warranted as best practice (Aarts & Caffee, 2005; Johnson, 2013).

Verification of a hearing aid is an objective measure which confirms it is operating appropriately (Jorgenson, 2016). Previous research has shown that best practices indicate probe microphone measurements should be completed to verify hearing aid output and gain, as well as offering audiologists' reassurance they provide quality products, which promotes greater satisfaction and benefit for their patients. Currently, these measurements are the only means of ensuring an audible signal. However, studies have reported that more than half of hearing health professionals did not use probe microphone measurements on a regular basis (Jorgenson, 2016). Some hearing health providers reported using alternative verification measures, like aided speech tests and manufacturer first-fit formulas, in order to provide accurate gain values. Reasons for not using probe microphone measurements included lack of finances, inadequate space for equipment, limited clinical time, and confidence the manufacturer "first-fit" approach was satisfactory. If probe-microphone measurements weren't used for verification, the alternative methods of verification should be evaluated. According to Mueller (2006), some alternate verification methods that are being used in the clinic include manufacturers automated prescription, simulated real-ear gain, and 2-cc couple measurements, to name a few. Each manufacturer has their preferred fit for their hearing aids, and while this can simplify the fitting process, research has shown that these preferred fittings can be very different from those validated verification methods. With simulated real-ear gain, manufacturers attempt to estimate the gain in the real ear. However, estimated and real-ear gain may not be matched. For example, Mueller (2006) found that the simulated gain was below the actual prescriptive target. The third alternative measurement could use 2-cc couplers; however, it might be difficult to predict real-ear gain based upon coupler gain. Therefore, real-ear measurements are necessary to ensure the proper fit and gain is provided for each individual patient.

It is interesting to note that some practitioners utilize simulated real-ear gain in the manufacturer software for optimizing hearing aid fit. However, differences may exist between hearing aid manufacturers' on-ear and simulated measurements (e.g., Hawkins & Cook,2003). The representations available to clinicians were simply simulations based on average performance values, not patients' individual responses or ear canal characteristics. As a matter of fact, to create insertion gain values, manufacturers in general utilize a specified average 2-cc coupler value for the chosen model, then adapt these values based on manufacturer-determined coupler output for flat insertion gain (CORFIG). However, because there are no universally accepted CORFIG values existed, variation may occurr between manufacturers and various hearing aid styles. It is recommended completing real-ear measurements to ensure a device is performing properly, as simulations are only a starting point for any hearing aid fitting (Hawkins & Cook, 2003).

In addition to insertion gain differences between formulas, perceived benefit of hearing aids by patients is a critical aspect of the hearing healthcare profession, and should not be overlooked. Abrams, Chisolm, McManus, and McArdle (2012) evaluated effects of self-perception of benefit as a function of hearing aid fitting procedures. During a period of eight weeks, participants were seen for three sessions, with half of the participants randomly assigned to be fit via manufacturer's initial-fit approach first, and the other half fit via a verified approach. Patient self-perceived benefit was measured with the Abbreviated Profile of Hearing Aid Benefit (APHAB), and were asked to base their answers on recalled experiences prior to amplification. Results revealed over half of participants preferred the verified approach. Results also revealed a significant difference between measured real-ear aided response (REAR) as related to the fitting method, with the initial-fit approach revealing less gain. Because of this increase in benefit for the patient when real-ear measurements are conducted, real-ear measurements should be considered part of routine patient care with hearing aid fittings.

However, there are arguments both for and against probe microphone measurements, and whether these measurements should be utilized on a regular basis in a clinical setting (Dillon & Keisder, 2003). Arguments for probe microphone measurement include software may not accurately adjust the hearing aid to achieve appropriate gain targets, and evidence thus far suggests we cannot yet rely on accuracy of simulations in hearing aid programming software. In addition, individual characteristics of patients' ears varies, affecting gain and output of the device in an individual's ear canal. Another argument in favor of measurement includes the distinction that probe microphone measurements can detect and reveal presence of any resonance peaks, which can affect sound quality, although these peaks may not be represented in simulations provided by manufacturers.

Arguments against use of probe microphone measurements should also be considered. One of these arguments states different prescription methods can produce varied results. Therefore, the question is raised of matching targets based upon a single formula, when multiple formulas exist, prescribe different amounts of gain, yet yield similar loudness preference and speech perception performance in hearing aid users. Dillon and Keidser (2003) responded to this question. They stated evidence supporting validity of all prescriptive targets was not equal, and suggested speech intelligibility maximization was preferred to loudness normalization. Therefore, these formulas produced different targets, however, it was discussed that very few formulas have been properly evaluated and compared with one another. Another argument against the use of probe microphone measurements is if a hearing aid is ultimately going to be adjusted according to patient preferences and not strictly according to targets, why spend time meeting targets? Although a valid concern, finding optimum settings based on patient feedback alone is a time consuming and unreliable process, unless settings are already close to final settings. Therefore, probe microphone measurements allow for a decrease in discrepancy between target and patient response, allowing for a decrease in fine tuning (Dillon & Keidser, 2003).

The purpose of this study was to investigate differences in prescriptive targets between generic prescriptive approaches (NAL-NL1, NAL-NL2, DSL v5) included in manufacturer fitting software and Audioscan's Verifit2 real-ear analyzer. It was hypothesized that REAR would vary with respect to target and that this variance would differ between manufacturers and across audiometric frequencies.

Methodology

Six hearing aid manufacturer softwares were explored and differences of prescribed gain as a function of frequency were compared. The hearing aid softwares included Starkey Inspire 2016.2 (z-series i30 hearing aid), Phonak Target 5.1 (Bolero Q50-M13 hearing aid), ReSound Aventa 3.10 (LS977-DW hearing aid), Signa (formerly known as Siemens) Connexx Eight 8.2 (Motion SA 5px hearing aid), Oticon Genie 2016.2 (Nera 85 hearing aid), and Widex Compass GPS (D-9 440 hearing aid). Two configurations of sensorineural hearing loss were explored: a flat 50 dB HL loss and a mild sloping to moderately severe loss. These configurations were selected to span the range of hearing losses seen in clinical practice, and is consistent with past studies (Johnson and Dillon, 2011). Two of the generic formulas were compared between manufacturers: NAL and DSL, as well as comparing differences in aided gain between experienced and new users implemented in each manufacturer's software. All hearing aids compared were behind-the-ear (BTE) with earmold and regular tubing, bilaterally.

Prescribed REAR targets for four frequencies (500Hz, 1kHz, 2 kHz, and 4 kHz) were obtained for a speech stimulus at 65 dB SPL in the fitting software of all manufacturers examined. All parameters were set to be as consistent as possible across all manufacturers, and all features, including directional microphone and noise reduction, were disabled. REAR targets for the same level of a speech stimulus were recorded from Audioscan's Verifit2 real-ear analyzer. Using the Verifit REAR targets as the baseline, the differences were compared between the prescribed REAR targets from each manufacturer and the Verifit for each generic prescription.

Results

Across generic fitting formulae, only three to four out of six manufacturers prescribed similar targets (within ± 5dB) compared to the Verifit. As mentioned by Johnson and Mueller (2016), the differences between values of output at each selected frequency were considered clinically significant when greater than +/- 5 dB. The biggest discrepancy was observed at 4 kHz in the present study. For the moderate flat loss, the REAR target differences between the six hearing aid manufacturers and the Verifit ranged from -18 to 20 dB for NAL-NL1, -8 to 13 dB for NAL-NL2, and -5 to 26 dB for DSLv5 across frequencies. For the mild-to-moderate sloping loss, the REAR target differences between the manufacturers and the Verifit ranged from -12 to 22 dB for NAL-NL1, -5 to 10 dB for NAL-NL2, and -9 to 26 dB for DSL v5. There was a large variability across manufacturers. Specifically, one manufacturer prescribed 10 to 26 dB more amplification at 1, 2 and 4 kHz compared to the Verifit.

NAL-NL1 REAR Comparisons

As seen in Table 1, the trend of the most output was evident at 2000 Hz, with the exception of hearing aid 3. The least amount of output was seen at 500 Hz, closely followed by 4000 Hz for hearing aids 1 and 2, in addition to the Verifit. Across frequencies, hearing aid 3 provided the most output as compared with the Verifit and other manufacturers.

As seen in Table 2, the trend of the most output evident at 2000 Hz was seen with hearing aids 1 and 2, with the most output provided for hearing aids 3-5 at 4000 Hz. The least amount of output provided was evident at 500 Hz across frequencies for NAL-NL1 new users with a sloping hearing loss. Across frequencies, hearing aid 3 provided the most output as compared with the other manufacturers and the Verifit.

As seen in Table 3, the most output provided across manufacturers was evident at 2000 Hz, with the least amount of output provided across manufacturers was evident at 500 Hz for NAL-NL1 with a flat loss. Similar output was seen at 500 and 4000 Hz across manufacturers as well, due to the flat nature of the hearing loss being examined. Across frequencies, hearing aid 3 provided the most output as compared with the other manufacturers and the Verifit.

As seen in Table 4, across manufacturers, hearing aid 3 provided the greatest output at 500, 1000, 2000, and 4000 Hz. At 500 Hz, hearing aid 3 provided the greatest output of 65 dB SPL, with hearing aid 5 provided the least output of 52 dB SPL. At 1000 Hz, hearing aid 3 provided 77 dB SPL of output, while hearing aid 2 provided the least output at 67 dB SPL. At 2000 Hz, hearing aid 3 provided 92 dB SPL of output, with hearing aid 4 provided the least output of 76 dB SPL. At 4000 Hz, hearing aid 3 provided the greatest outputof 98 dB SPL, with hearing aid 2 provided the least amount of output at 73 dB SPL.

NAL-NL2 REAR Comparisons

As seen in Table 5, the most gain provided across frequencies was evident at either 2000 Hz or 4000 Hz, dependent upon the manufacturer. Hearing aid 3 provided the most output at each individual frequency, with the most provided at 4000 Hz. Hearing aid 5 provided the least output at 500 Hz (58 dB), with the largest amount of output provided by hearing aid 3 at 4000 Hz (84 dB).

As seen in Table 6, the most output provided across frequencies was seen at 4000 Hz. Hearing aid 3 provided the most output as compared with the other manufacturers at 2000 and 4000 Hz, and was comparable with the others at 500 and 1000 Hz. Hearing aid 5 provided the least amount of output at 500 Hz as compared with the other manufacturers (52 dB SPL), and hearing aid 4 providing the least amount of output at 4000 Hz (76 dB SPL).

As seen in Table 7, across manufacturers, the most output was provided at 4000 Hz, with the exception of hearing aid 6. However, the Verifit provided the most output at 2000 Hz, with hearing aid 6 reflecting this similar pattern. Hearing aid 3 provided the most output across frequencies, with the most output at 4000 Hz (84 dB SPL). The least amount of output provided was by hearing aid 5 at 500 Hz (58 dB SPL).

As seen in Table 8, across manufacturers, the most output was provided at 4000 Hz, while the least amount of output was provided at 500 Hz. Hearing aid 3 consistently provided the most output across all frequencies as compared with the Verifit and the other manufacturers. At 500 Hz, hearing aid 5 provided the least amount of output at 53 dB SPL, while hearing aid 3 provided the most output with 65 dB SPL. Hearing aid 6 provided the least amount of output at 4000 Hz with 76 dB SPL, while hearing aid 3 provided the most output at 4000 Hz with 87 dB SPL.

DSL v5 REAR Comparisons

As seen in Table 9, across manufacturers, hearing aid 3 provided the most output across frequencies, with the greatest amount at 4000 Hz (98 dB SPL). Overall across manufacturers, the most output was provided at 2000 Hz or 4000 Hz, with the least amount of output provided by hearing aid 5 at 500 Hz (67 dB SPL).

As seen in Table 10, across manufacturers, the most output was provided at 4000 Hz, and the least was provided at 500 Hz, consistent with the hearing loss. Hearing aid 3 provided the most output across frequencies, with the most output at 4000 Hz (105 dB SPL). Hearing aids 1 and 2 provided the least amount of output at 4000 Hz (79 dB SPL). At 500 Hz, hearing aid 3 provided the most output at 67 dB SPL, while hearing aid 5 provided the least amount of output at 56 dB SPL.

Discussion

The overall purpose of this study was to examine the possible differences of prescriptive targets for adults between the generic prescriptive approaches in the manufacturer fitting software and the Audioscan Verifit2 real-ear analyzer. It was hypothesized that REAR would vary with respect to target and that this variance would differ between manufacturers and across audiometric frequencies. Specifically, the estimated real ear aided responses for NAL-NL1, NAL-NL2, and DSLv5 within the six manufacturers were examined and compared with the Verifit targets for each of these prescriptive approaches.

For the same generic prescriptive method and the same degree of hearing loss, the REAR varied across hearing aid manufacturers and the real-ear analyzer. For example, NAL-NL1 for an experienced hearing aid user with a flat 50 dB hearing loss, prescriptive REAR of gain varied by at least 12 dB. The least difference occurred at 1000 Hz, while the greatest difference occurred at 4000 Hz. As seen in Figure 1 and Tables 1 through 4, the largest difference seen was 13 to 14 dB above the Verifit targets at 2000 Hz, and 20 to 22 dB greater than the Verifit targets at 4000 Hz. In addition, for inexperienced users, hearing aid 5 significantly under-amplifies 12-18 dB below Verifit targets at 500 Hz, while over-amplifying by 10 dB at 4000 Hz. All other hearing aids were within +/-5 dB of the Verifit targets. In Figure 3 and Tables 9 and 10, other than those noted previously, the other hearing aids were within +/- 10 dB from the Verifit targets, most of which were within 5 dB of the Verifit prescriptive targets. According to Johnson and Mueller (2016), differences between values of output at each selected frequency were considered clinically significant (greater than +/- 5 dB).

The major finding of this study was that prescribed output gain values provided by each generic formula for several manufacturers varied significantly with respect to target, despite hearing loss configuration and user experience. These results were consistent with the hypotheses made; experienced users were provided greater output gain than new users, and the aided response varied across audiometric frequencies and manufacturers. It was found that hearing aid 3 consistently provided greater levels of output than the other manufacturers, in relation with the Verifit output targets. Experienced user gain outputs were consistently closer to the Verifit output targets, while the new user targets were greater than or less than the Verifit targets. This outcome has been reported previously (e.g., Warman, 2014). These findings have implications, especially clinically, because often the initial fitting formula of a manufacturer is applied, without verification per real-ear measures. In accordance with Aarts and Caffee (2005), results suggest audiologists should consider using individual real-ear measures in adult hearing aid fittings until manufacturer software is shown to accurately predict real-ear hearing aid performance. Further study of the differences between values of insertion gain seems warranted.

Conclusion

For the same generic prescriptive method and the same degree of hearing loss, simulated REAR varied across hearing aid manufacturers, and in many cases differed from the prescriptive target. It appeared that hearing aid manufacturers and real-ear analyzers may adapt different parameters to implement generic prescriptions to prescribe targets. It is critical for clinicians to not only do real-ear measurements and verify the output in the individual ear canal, but also to thoroughly understand how targets are determined for the purpose of fine tuning. Caution is advised when comparing targets across different real-ear analyzers, as only one real-ear analyzer was examined during this study.

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Figures and Tables

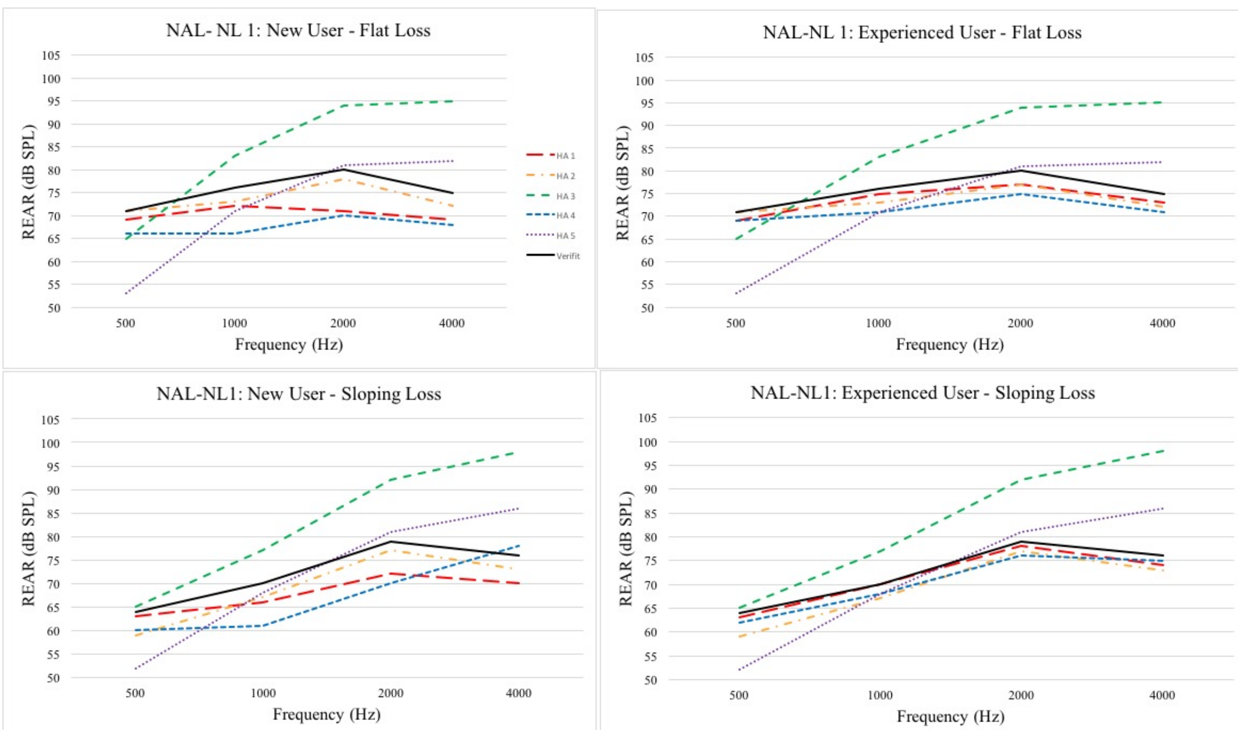

Figure 1: Prescribed Real Ear Aided Response (REAR) as a function of frequency in NAL- NL 1 algorithm across manufacturers for flat and sloping configurations, across new and experienced hearing aid users.

Table 1: REAR targets in NAL-NL1 algorithm for new users with a flat loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	71	76	80	75
Hearing Aid 1	69	72	71	69
Hearing Aid 2	71	73	78	72

Hearing Aid 3	65	83	94	95
Hearing Aid 4	66	66	70	68
Hearing Aid 5	53	71	81	82

Table 2: REAR targets in NAL-NL 1 algorithm for new users with a sloping loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	64	70	79	76
Hearing Aid 1	63	66	72	70
Hearing Aid 2	59	67	77	73
Hearing Aid 3	65	77	92	98
Hearing Aid 4	60	61	70	78
Hearing Aid 5	52	68	81	86

Table 3: REAR targets in NAL-NL1 algorithm for experienced users with a flat loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	71	76	80	75
Hearing Aid 1	69	75	77	73
Hearing Aid 2	71	73	77	72
Hearing Aid 3	65	83	94	95
Hearing Aid 4	69	71	75	71
Hearing Aid 5	53	71	81	82

Table 4: REAR targets in NAL-NL1 algorithm for experienced users with a sloping loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	64	70	79	76
Hearing Aid 1	63	70	78	74
Hearing Aid 2	59	67	77	73
Hearing Aid 3	65	77	92	98
Hearing Aid 4	62	68	76	75
Hearing Aid 5	52	68	81	86

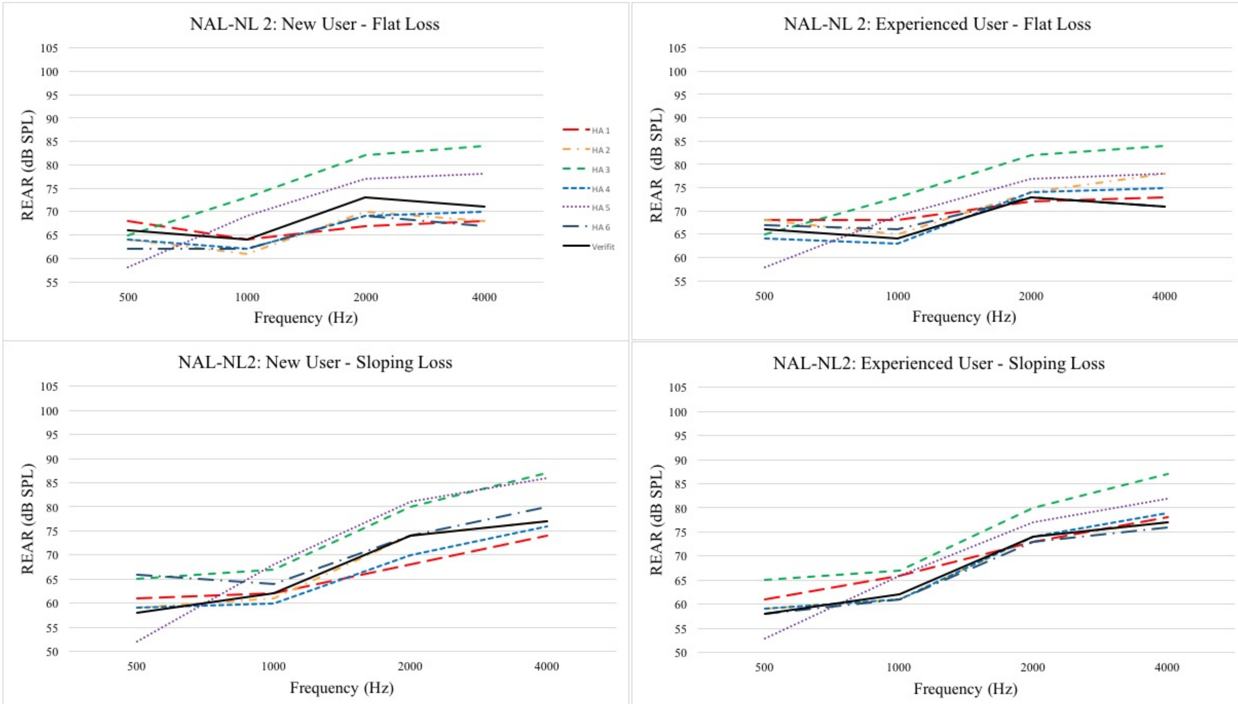

Figure 2: Prescribed Real Ear Aided Response (REAR) as a function of frequency in NAL- NL 2 algorithm across manufacturers for flat and sloping configurations, across new and experienced hearing aid users.

Table 5: REAR targets in NAL-NL2 algorithm for new users with a flat loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	66	64	73	71
Hearing Aid 1	68	64	67	68
Hearing Aid 2	64	61	70	68
Hearing Aid 3	65	73	82	84
Hearing Aid 4	64	62	69	70
Hearing Aid 5	58	69	77	78
Hearing Aid 6	62	62	69	67

Table 6: REAR targets in NAL-NL2 algorithm for new users with a sloping loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	58	62	74	77
Hearing Aid 1	61	62	68	74
Hearing Aid 2	59	61	74	77
Hearing Aid 3	65	67	80	87
Hearing Aid 4	59	60	70	76
Hearing Aid 5	52	68	81	86
Hearing Aid 6	66	64	74	80

Table 7: REAR targets in NAL-NL 2 algorithm for experienced users with a flat loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	66	64	73	71
Hearing Aid 1	68	68	72	73
Hearing Aid 2	68	65	74	78
Hearing Aid 3	65	73	82	84
Hearing Aid 4	64	63	74	75
Hearing Aid 5	58	69	77	78
Hearing Aid 6	67	66	73	71

Table 8: REAR targets in NAL-NL 2 algorithm for experienced users with a sloping loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	58	62	74	77
Hearing Aid 1	61	66	73	78
Hearing Aid 2	59	61	74	77
Hearing Aid 3	65	67	80	87
Hearing Aid 4	59	61	74	79
Hearing Aid 5	53	66	77	82
Hearing Aid 6	58	61	73	76

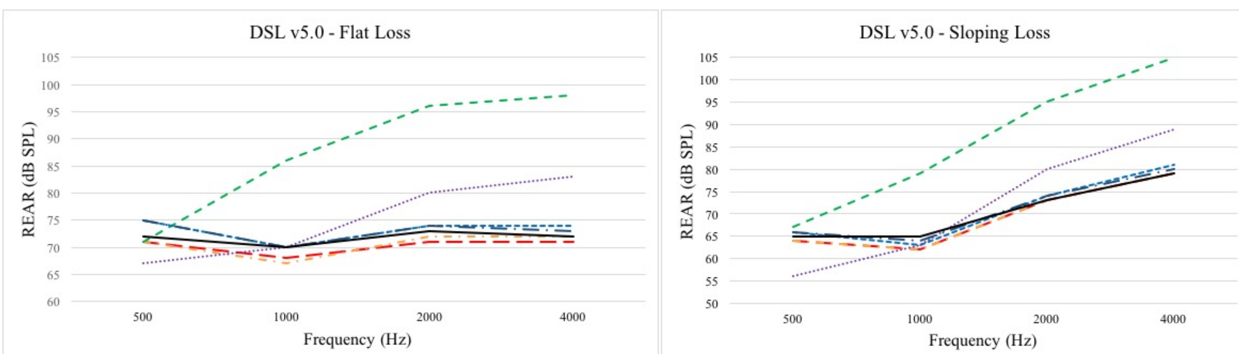

Figure 3: Prescribed Real Ear Aided Response (REAR) as a function of frequency in DSL algorithm across manufacturers for flat and sloping configurations.

Table 9: REAR targets in DSL v5 algorithm for a flat loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	72	70	73	72
Hearing Aid 1	71	68	71	71
Hearing Aid 2	71	67	72	72
Hearing Aid 3	71	86	96	98
Hearing Aid 4	75	70	74	74
Hearing Aid 5	67	70	80	83
Hearing Aid 6	75	70	74	73

Table 10: REAR targets in DSL v5 algorithm for a sloping loss.

	500 Hz (dB SPL)	1000 Hz (dB SPL)	2000 Hz (dB SPL)	4000 Hz (dB SPL)
Verifit	65	65	73	79
Hearing Aid 1	64	62	73	79
Hearing Aid 2	64	62	73	79
Hearing Aid 3	67	79	95	105
Hearing Aid 4	66	63	74	81
Hearing Aid 5	56	63	80	89
Hearing Aid 6	66	64	74	80