WHITEPAPER
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Client Target and real-ear measurements

INTRODUCTION

Picture the scenario described below...

A client walks into the clinic, ready and excited for his hearing aid fitting. The clinician follows Oticon's recommended fitting flow, filling out answers to personalisation questions, running the feedback manager in Genie, and so forth. The client is a first-time user and he is concerned about having a hearing aid in his ear. The clinician decides to fit him with open domes binaurally to give him a good first fitting experience, even though open domes are not prescribed for the client's hearing loss. The clinician looks at the displayed target and simulated gain curves – they match up perfectly. The client, however, has a less than satisfied look on his face and says, "I can't really tell much of a difference", or, "I don't really like the way this sounds". In this situation, chances are good that the answer lies in a discrepancy between what the clinician sees in the simulated gain curves and what the client is hearing in his ears.

This document explains how the graph view has changed for all rationales in the new Genie 2 fitting software in order to make it clear to the clinician how much amplification the client is getting in comparison to the prescriptive rationale. Client Target is the Genie 2 fitting software concept designed to help the clinician achieve even more successful first fittings, right from the start. Previously, Client Target has been called Rationale Target and it was implemented in 2014 for the generic DSL rationale in Genie (Neel Weile, 2014). It is now being implemented more widely, as part of Genie and Genie 2 fitting software.

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The previous view in Genie

The scenario described in the introduction depicts a situation that might happen using the previous display curves in Genie. The clinician chose an open dome instead of, in this instance, the prescribed bass dome double. Figure 1 shows the precribed dome in 1a and the chosen open dome in 1b. Both show the simulated target line (solid red) overlaying the prescribed target line (dotted line and not visible here). Looking at the graphs, the clinician is not alerted to the fact that they may not be providing appropriate gain, because the target gain changes with the change in acoustics.

The main reason for this previous view is that it presents a cleaner, neater picture of the fitting and when the client appears to be happy, this is a nice feature for the fitter. However, when a choice in acoustic parameters prevents the clinician from reaching appropriate gain levels, then it would be helpful for the clinician to know. The purpose of introducing a new Client Target graph view, is to give the clinician more transparency when it comes to the implications of acoustic fitting choices.

The new Client Target view in Genie 2

Let's look further into what Client Target means for the clinician. Essentially, Client Target enables the clinician to see and balance the trade-off between optimal audibility and the comfort preference of the client. It is available in Genie 2, Oticon's new fitting software used to fit the Opn line of hearing aids. It is also available in Genie for DSL, NAL-NL1 and NAL-NL2. The rationales currently implemented in Genie 2 are the proprietary VAC+ rationale, NAL-NL1 and NAL-NL2. One advantage is that clinician can now see the prescribed VAC+ targets more transparently.

Client Target is a great tool to help the clinician make the best possible and most informed decisions for the client. The following sections cover these relevant topics:

1) Changes to the target curve display
2) Matching targets in the software
3) Target frequencies in graph view
4) Input signals and targets

Changes to the target curve display

There are two important benefits associated with the new display of target curves. Firstly, Client Target adds transparency to the fitting session so the clinician can see the effects of their acoustical choices more clearly. Secondly, the graph view will correspond largely to the graph view experienced when verifying the fitting using external real ear measurement (REM) equipment. The topic of REM verification is covered in a later section.

As seen in Figure 1, the target curves and simulated curves match perfectly in the old view. In Figure 2a and 2b, the same fitting is shown using Client Target view. It is now immediately obvious to the clinician that there is a large discrepancy between the target curve (dotted line) and the simulated curve (solid), especially below 2000 Hz. The use of the open dome in Figure 2b is causing the client to lose access to a substantial amount of gain, across the frequency spectrum and across input levels. The prescribed bass double dome is not as open, and consequently, more sound reaches the client's eardrum (2a). However, as can be seen, prescriptive targets are not met below 500 Hz and this is a well-known phenomenon with semi-open fittings. The clinician can now see the discrepancy between rationale targets and achievable gain in the fitting.

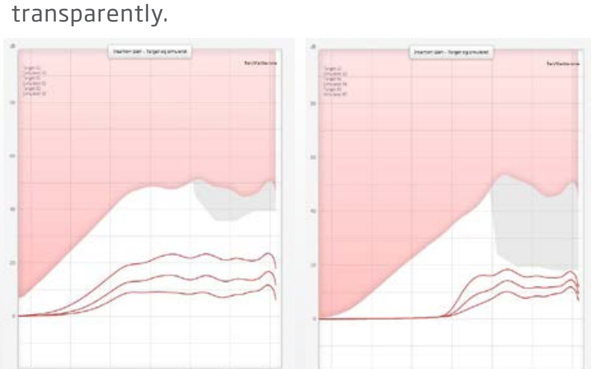

Figure 1. 1a shows a screenshot of the previous view where the clinician chose the prescribed bass dome double for the hearing loss. 1b shows the same fitting where the clinician has chosen an open dome. Both figures show a perfect match between the target and simulated curves.

Figure 2. 2a shows Client Target view for the same fitting as shown in Figure 1. The prescribed bass dome double is shown in 2a and the chosen open dome is shown in 2b. The estimated feedback limit is shown in both.

If the client complains that sounds are not loud enough, then showing the clinician the low-frequency roll-off can guide the decision to fit a more closed dome, rather than attempting to turn up gain in an area where no more can be given due to purely acoustic limitations. It is important to remember that nothing has changed with respect to the actual gain prescription in Oticon Opn hearing aids. Client Target solely represents graphical changes and additions to the fitting software.

So what does Client Target mean? As before, for all rationales, targets are calculated based on the client's hearing thresholds, their age and gender, and the real-ear-to-coupler-difference (RECD), real ear unaided response (REUR) and uncomfortable loudness level (UCL) when appropriate and available. What has changed is that target calculation for all rationales is no longer dependent on the style of hearing aid, the coupling chosen, and the venting/dome chosen. Consequently, the difference can now be seen between the "pure" targets and the simulated match to those targets with the style, coupling, and venting/dome choices made by the clinician. Figure 3 illustrates how different dome choices can change how well the simulated curve matches the target curve. With Client Target, these changes are now visible to the clinician.

Matching targets in the software

As hearing care professionals, we are used to looking at graphs, curves, and numbers every day. We rely on them to tell us what our clients are hearing and what we can expect the hearing aid to be doing. However, we should not expect a simulated gain curve to match perfectly to a target curve because a simulation is just that – a simulation.

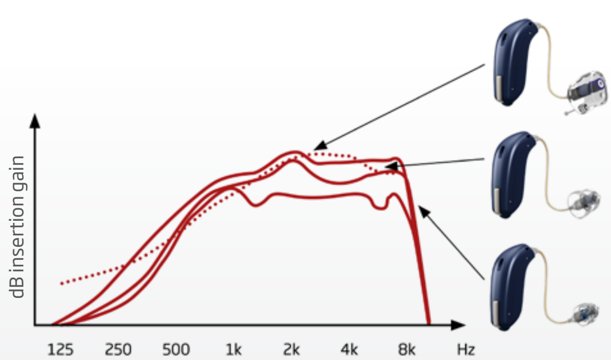

Figure 3. A theoretical example of how choice of acoustics affects how well the simulated curves (solid) match the target curve (dotted). In this case, a more closed option leads to a superior target match.

One obvious question comes up in this regard: let's say the clinician has fit the client with an appropriate hearing aid style and followed the recommendation for a prescribed vent. He looks at the Client Target view and sees that there is a marked difference between the simulated curve and the target curve. Why?

Target prescriptions from an independent organisation, such as National Acoustic Laboratories, make necessary assumptions about hearing aids characteristics that sometimes do not correspond with the hearing aids on the market. This is unavoidable due to the wealth of products available. These fitting rationales are well-founded in research and are widely used. A discrepancy can arise when the generic fitting rationale cannot factor in specific characteristics of the hearing aid, such as its adaptive compression speed or the number of bands implemented. If the exact characteristics have not been accounted for in the generic fitting rationale, then the realisation of gain in our hardware will inevitably require compromise or at the very least, room for interpretation in the target implementation.

For VAC+, Oticon's proprietary rationale, the simulated curve will usually correspond very closely to the target curve. Differences may still occur because Oticon has made a deliberate choice not to include effects of acoustics and potential limitations due to predicted feedback risk in the target calculation. The VAC+ target reflects the amplification needed to compensate for the client's loss of audibility. Often though, clients prefer more open fittings than what is optimal in terms of audibility. Allowing the clinician to see and balance the trade-off between optimal audibility and the comfort preference of the client is a helpful counselling and decision tool for the clinician, regardless of the rationale chosen.

It should become increasingly clear that target match is not black or white, but rather a nuanced issue that should be treated as such. This is the primary reason for the Client Target view which allows a higher degree of transparency into the fitting process. Some clinicians may ask: Does this mean Oticon matches targets less accurately than before? The answer is no: there is no change in how gain is prescribed and therefore no change in how closely we are matching target – only the view of the target match has changed. Client Target is the new tool for clinicians to guide them through a successful fitting based on good balance between sufficient target match and good sound quality.

Target frequencies in graph view

When a clinician wants to evaluate how well they match targets in the fitting software, they look to the graphs to give them this indication. As part of the new Client Target view, the graph view is now more true to the prescriptive rationales used. Let's illustrate this with an example:

In previous Genie versions (Figure 4), both the solid simulated curve and the dotted target curve extend from below 125 Hz and well past 8000 Hz in the graph. Since the frequency range of some Oticon hearing aids extends from 100- 10000 Hz, it always makes good sense to show a simulated curve that includes these frequencies. However, for the target curve, the situation is different.

National Acoustic Laboratories (NAL) in Australia provides targets for their NAL-NL1 and NAL-NL2 rationales from 250-8000 Hz and other generic rationales provide a similar or narrower target range. Therefore, in the Client Target view, targets are now only shown between 250-8000 Hz to reflect that this is the widest range of gain targets provided (Figure 5). In other words, target values are no longer extrapolated into frequencies where no targets have been defined. This avoids unnecessary guesswork surrounding target match in frequencies where no targets are officially available. In addition to this, targets will only be shown for broadband speech-shaped signal types. In Genie and Genie 2, this includes ANSI S3.5, ANSI S3.42, IEC-645-2, ISTS, and NAL speech.

Input signals and targets

A part of Client Target is the new default input signal view in the Fine-tuning screen of Genie 2. In the old view, the default input signal was Pure/Warble tone. In Client Target in Genie 2, the default input signal is the ANSI S3.5 standard signal (shown in Figure 5), an artificial noise signal with speech-like spectral and temporal properties, also known as ICRA noise. This speech-shaped composite signal has the same Long Term Average Speech Spectrum (LTASS) as speech signals, but is stable and without significant variation in intensity and frequency in the short-term. Today, it is the signal used for hearing aid calibration. It makes good sense for ANSI S3.5 to be the default graph view in Genie 2 because it closely represents the normal speech signal and hearing aids should closely match the rationale targets in this view, as opposed to pure tones which are not an accurate representation of real world sounds. In the Client Target view, rationale targets are now only displayed for speech-shaped signal types: ANSI S3.5, ANSI S3.42, IEC 645-2, ISTS ,and NAL speech. Genie preserves the selected signal from the previous session, so the clinician is advised to make sure ISTS or ANSI 3.5 are selected if they used pure-tone warble before.

REM in Genie 2

Updates have been made to the REM tab in the task pane in Genie 2, Figure 6. The goal of these changes is to allow for quick and easy target match when verifying targets in external REM equipment and making sure that the Opn hearing aids are set in a way that makes sense for REM. The very adaptive nature of the new Opn technology means that in order to obtain a realistic measurement of gain throughout the 10-20 second REM, the adaptive setting can optionally be deactivated by choosing the Pinna Omni setting. When entering the REM tool, the clinician has two choices: verification using speech signals and verification using noise signals. As described in the REM cookbook, the

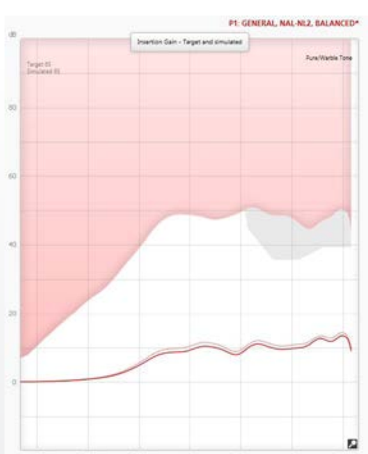

Figure 4. The previous view: simulated and target curves both extend the whole length of the frequency range, <125 - >9000.

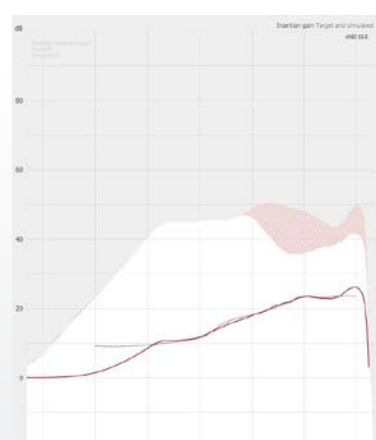

Figure 5. The dotted target curve is shown from 250-8000 Hz, consistent with the provided targets from NAL. The input signal view is ANSI S3.5.

majority of clinicians verify targets using real-speech signals, such as the International Speech Test Signal (ISTS). For easy and fast REM, we recommend choosing the default settings for speech signals, and then running the REM and adjusting accordingly, if necessary. Once the clinician leaves the REM tab, settings chosen in Fine-tuning are automatically restored and any changes made to gain during REM are transferred.

REM Autofit

A good alternative to performing REM on external REM software is the REM AutoFit module in Genie and Genie 2. Due to this function, it is now possible to complete REM in under 6 minutes (Crowe et al, 2016). By communicating with the REM equipment, the gain is automatically adjusted to match targets using ISTS, without having to launch independent REM software. The clinician still has the possibility of manually fine-tuning the hearing aids. Targets are also visible for VAC+. For more details, the REM AutoFit QuickGuide is now available.

The REM Cookbook & Opn verification guidelines

Verifying hearing aids using external real ear measurement (REM) equipment can at times be frustrating to clinicians due to measurements not turning out as expected or because of unnecessary complexity in the process. The REM Cookbook is a guide available from Oticon that can help the clinician perform real ear measurements easily and correctly. The guide also provides trouble-shooting tips when REMs do not turn out as expected. An important consideration is that the acoustics, style, rationale, input signal and client information choices made in Genie 2 must be comparable to the choices made in the external equipment.

Moreover, a detailed guide on verification of the OpenSound Navigator feature in the Opn hearing aid line is now available for five popular REM equipment manufacturers. The guides contains instructions on how to prepare the hearing aids and REM equipment, as well as on how to conduct the measurements. The guides include explanations on how to perform audibility verification and OpenSound Navigator feature verification, including advanced signal processing. For each measurement indications are given on how to interpret the curves.

Performing REMs on external equipment

Fitting software is designed with the needs of many different clinician types in mind. Some clinicians like to use the first fit and rely only on client feedback for adjustments. Others verify their fittings with real ear measurements as part of their daily routine, either as a mandatory requirement or because they find value in the information it gives. For this last group of clinicians, it is useful to know a bit about how generic rationales are implemented into measurement equipment.

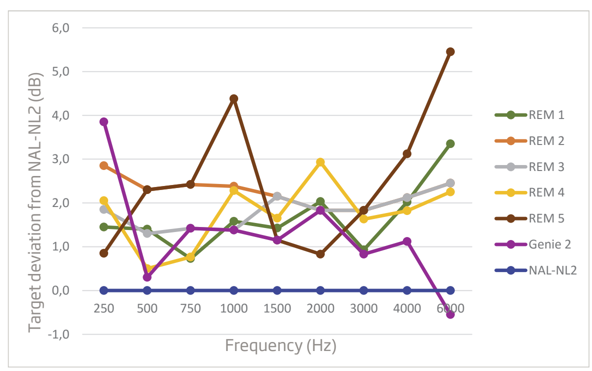

Figure 7. REIG target deviation from pure NAL-NL2 targets for external REM equipment software and Genie 2 at 65 dB SPL input level using a standard N3 audiogram (Bisgaard et al 2010)

Figure 6. The new REM settings pop-up in Genie 2. This allows you to set Opn correctly and ensure good alignment with external REM equipment.

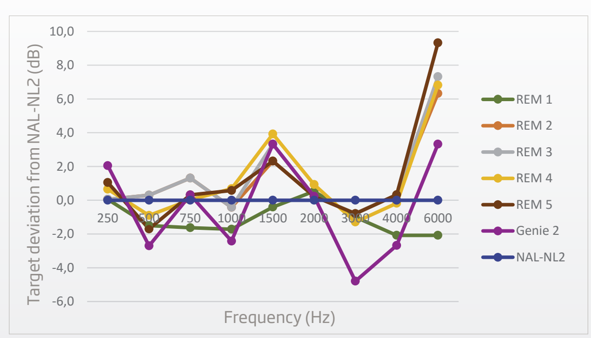

Figure 8. Internal investigation of REAG target deviation from pure NAL-NL2 targets for external REM equipment software and Genie 2 at 65 dB SPL input level using a standard N3 audiogram (Bisgaard et al 2010). Other input levels and N2 audiogram results are not shown here.

An internal investigation was conducted looking into how generic rationale targets across equipment might deviate from the pure generic rationale targets as made available by the rationale providers. The NAL-NL2 targets provided by National Acoustic Laboratories were compared to the NAL-NL2 targets implemented by five major REM equipment manufacturers, as well as the Genie 2 implementation (Figure 7 & 8). Targets were calculated for two standard audiograms, N2 (mild sloping) and N3 (moderately sloping) (Bisgaard et al, 2010) and both Real Ear Insertion Gain (REIG) and Real Ear Aided Gain (REAG) targets were investigated.

Generally, the implemented software targets did not deviate substantially from the pure NAL-NL2 targets. For REIG, the maximum deviation was about 5 dB and for REAG about 9 dB. Such large deviations were mostly seen at the higher frequencies. On average, the deviation was between 1-3 dB but it varied with both equipment and input level (50, 65, and 80 dB SPL input targets were calculated).

The main reason for these deviations is not careless implementation or equipment inaccuracy. Rather, these results illustrate that the software settings play a very important role. If the settings are not adjusted to match each other exactly, then target deviations become quite large. This is problematic when each software (from NAL, hearing aid manufacturer, and REM equipment manufacturer) can have different settings and parameters that are adjustable. A few examples are given below.

Gender

The NAL-NL2 rationale prescribes targets based on the client's gender. Targets are higher for male clients than for female clients. Targets vary if the client's gender is set to unknown as well. Most of the REM software offers the possibility to choose the client's gender. Some software however, does not provide any information on the client's gender. Consequently, when comparing a target curve from non-gender prescribed software to gender-prescribed software, the curves risk being different even if the rest of the settings are the same.

Experience level

Another factor that can create deviations among target curves from different software is experience level. NAL-NL2 adjusts the targets based on whether the client is a new or experienced hearing aid user. The targets for new users are lower than for experienced users. Some software manufacturers prefer to exclude this option for various reasons. If a software only includes targets for experienced users, the curve will not be comparable to a target curve meant for new users. Therefore, it is important to know which options are included in different software.

Wideband compression threshold

Wideband compression threshold is a setting that can be difficult to find, but small differences for this value amongst software can create quite different target curves. In conclusion, although the deviations caused by some of these individual settings might be small, they add up if several settings are different from one software to another. These deviations are additional to the ones that inevitably exist due to the different application formulas used by manufacturers for fitting rationales. This is why it is important to be aware of software settings if the fitting software targets are to be compared with REM equipment targets.

Individual ear canal variability

The investigation described above illustrates the importance of considering slight deviations when concluding on how well a hearing aid matches REM targets. As described by Gatehouse et al (2001), target match should be seen a target range match, not an exact point-to-point match on a curve. This is because of sometimes unavoidable measurement inaccuracies,

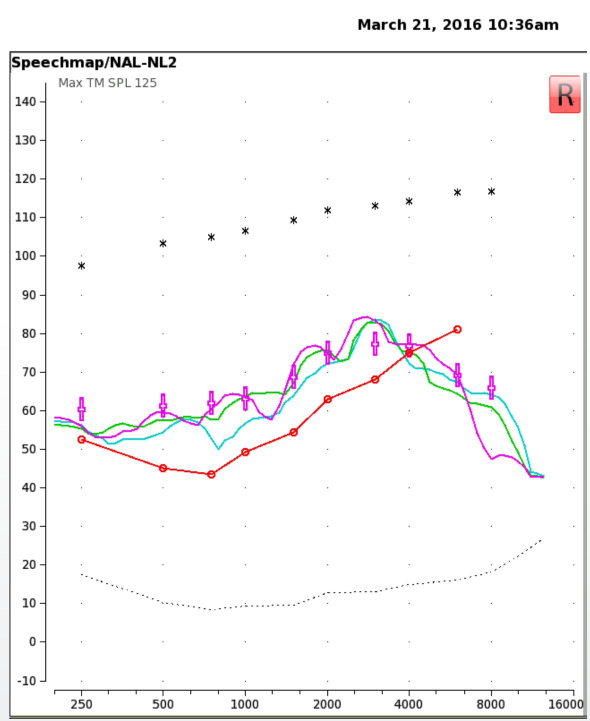

Figure 9. The effect of individual ear canal differences on target match using external REM equipment for three test subjects.

unavoidable target implementation inaccuracies, and unavoidable variations caused by putting a foreign object – a hearing aid – into ear canals that vary in shape and size.

To illustrate this last point, measurements were conducted on three different female test subjects under identical conditions. A miniRITE style hearing aid was programmed using the NAL-NL2 fitting rationale. The anti-feedback system and noise reduction were turned off and the directionality was set to omni-directional. An audiogram corresponding to a N3 (moderate) hearing loss was plotted into the fitting software. The prescribed dome was a bass double vent dome, which was then used for the measurements.

The results of the three measurements are shown in Figure 9. Although the target was identical for all three test subjects, the gain curves differed. Why? The only aspect that varied from one subject to another was their individual ear canal characteristics. The pink curve is the result of an ear canal with a higher amount of cerumen and for this subject, the target at 8000 Hz could therefore not be met without gain adjustments. The blue curve belongs to a subject who has had several middle ear complications and eardrum perforations as a child. Every ear canal has its individual characteristics and these affect how targets are actually realised. This means that there will always be a difference between the simulated Client Target view in Genie 2 and real-ear target match in external equipment. The point here is to underscore the importance of fitting to a target range, not an exact point on a curve, as described by Gatehouse et al (2001).

In summary

This document has shown the ways in which the graph view has changed for rationales in Genie and Genie 2 fitting software. Client Target is designed to help the clinician achieve even more successful first fittings, right from the start. It also allows the clinician to see and balance the trade-off that sometimes occurs between optimal audibility and the comfort preference of the client. In this scenario, Client Target is a very helpful counselling and decision tool for the clinician.

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