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REM AutoFit: speed and accuracy

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SUMMARY

Real ear measurements (REMs) offer several well-documented benefits. However, it is neccesary to invest some time into the procedure to experience the benefits. REM AutoFit in Genie 2 aims to lower the "cost" of this investment. Genie 2 | 2019.2 sees the introduction of A) an option to use speech mapping in REM AutoFit with IMC 2 compatible systems and B) support for simultaneous binaural measurements on Verifit®2 when REM AutoFit is used with Verifit®*LINK*.

The present study examines 1) time and accuracy when REM AutoFit is used with IMC 2 compatible systems, and 2) the further time savings offered when simultaneous binaural measurements are performed using REM AutoFit with Verifit*LINK* compared to sequential binaural measurements.

Using REM AutoFit with IMC 2, this study shows that the hearing care professional can complete the automatic target matching sequence at 3 input levels in under 2 minutes with a match to target that is equivalent to that of the clinician's manual approach. The present study also shows that the introduction of simultaneous binaural measurements in REM AutoFit with Verifit*LINK* results in a significant reduction in time to perform the automatic match to target sequence.

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Introduction

Ears vary. In fact, they vary a lot. One person's ears can have quite a different size, shape and ear drum compliance to the next person's ears. Unsurprisingly, this results in significant variation in the acoustics of peoples' ears and subsequently the sound that reaches the ear drum (Valente et al., 1991). Other than the audiogram, fitting software from any manufacturer usually does not have all the information about the acoustics of the client's ear canal so it has to use estimates based on average real ear data to prescribe the amplification for an individual ear which by definition is not average. The same is true for the positioning and acoustic leakage of the earpiece in the ear canal which can both vary from one fitting to the next. Furthermore, hearing care professionals (HCPs) can make further fine-tuning adjustments based on clients' subjective feedback during the fitting and of course the client may have some control over the sound themselves through volume control and smart-device apps. Thus, when the HCP or client makes these adjustments, it is necessary to ensure that they start from a place that they know is optimized for the client's ears and so that any further adjustments are based on amplification appropriate for those ears. The only way to do this is to measure the actual gain/output that is reaching the ear drum.

Performing Real Ear Measurements (REMs) has well-documented benefits, such as an improved perception of both the hearing aids and the HCP (Amlani et al., 2016), help in reducing the need for return visits when combined with validation (Kochkin, 2011), and improving hearing aid benefit (Abrams et al., 2012; Kochkin et al., 2010). Despite this, REMs are not always performed during hearing aid fitting (Kochkin, 2011). There are a variety of possible reasons why this is so, including the time taken to perform REMs and their perception as a cumbersome process.

For several years now, Oticon has offered the automated REM tool in Genie and Genie 2, REM AutoFit, which aims to make life easier for those HCPs who perform REM, as well as make the process more accessible to those who find conventional REM too time-consuming or cumbersome to include routinely in their fitting appointments. With the advent of communication protocols such as HIMSA's Inter Module Communication protocol 2 (IMC 2) and Audioscan's Verifit*LINK*, Oticon has developed REM AutoFit to be able to communicate with as many REM systems on the market as possible. At time of writing, the list of systems includes Interacoustics, MedRx, Auditdata, Audioscan, Otometrics and Siemens.

For those HCPs who find REM cumbersome, there are many ways in which REM AutoFit addresses this.

- The measurement and adjustment sequence required to meet target is all done automatically with the single click of a button. Manual adjustments and measurements are also available.
- The hearing aids are automatically muted during the open-fit equalization/calibration tone, which itself is automatic.
- There is no need to open multiple software applications. Measurements are controlled and displayed in Genie 2.
- There is no need to enter measurement parameters into REM software. The appropriate parameters are selected by REM AutoFit.
- Instructions and pictograms are offered throughout the workflow to guide the HCP.
- REM AutoFit with IMC 2 allows verification using VAC+ and DSE (Oticon's proprietary rationales).
- To view REM results later, the HCP has easy access to REM AutoFit results directly from Noah (Fast Data View) without the need to open REM software or fitting software.

For those HCPs who are under time constraints or who would simply like to be able to complete REMs faster, REM AutoFit addresses this by automating the target-matching process with the express aim of making the process fast without compromising match to target. Using REM AutoFit with Verifit*LINK*, has already been investigated, confirmed and published in a study at the University of Western Ontario (Folkeard et al, 2018).

The present study investigates whether this is also the case for REM AutoFit when used with IMC 2 compatible REM systems.

In Genie 2 | 2019.2, there are 2 main updates to REM AutoFit:

Update 1: Introducing speech mapping in IMC 2

Until now, REM AutoFit, when used with IMC 2 compatible REM systems, has used insertion gain measurements (including mandatory Real Ear Unaided Gain (REUG) and Real Ear Insertion Gain (REIG) in the workflow) to calculate the automatic adjustment to apply. However, speech mapping, using Real Ear Aided Response (REAR) targets

and measurements, is a popular alternative to insertion gain due to its clear display of audibility of amplified speech in the context of the client's residual dynamic range. This lends itself well to supporting the HCP in counselling the client. From Genie 2 | 2019.2, REM AutoFit offers speech mapping with IMC 2 compatible REM systems as an alternative to the existing gain-based verification (see figure 1). When using speech mapping, REM AutoFit displays REAR measurements and calculates automatic adjustments based on REAR in an output view that includes audiometric data and key measurements such as Speech Intelligibility Index (SII)*, percentiles* and Maximum Power Output (MPO)*.

Update 2: Upgrading binaural measurements with Verifit*LINK*

In Genie 2 | 2018.2, Oticon introduced REM AutoFit with Verifit*LINK*, which uses speech mapping as a measurement protocol. This widened the list of compatible REM systems to include Audioscan's Verifit1** and Verifit2. As with REM AutoFit when used with IMC 2 compatible REM systems, binaural measurements and automatic adjustments are performed with just a single click of a button. However, these measurements are sequential in REM AutoFit with Verifit*LINK* when used with Genie 2 | 2018.2 or 2019.1. From Genie 2 | 2019.2, it will be possible to perform measurements and automatic adjustments on both sides simultaneously with Verifit2 (with software version 4.18 or later). Furthermore, Audioscan's Binaural Sound Field Assist tool has been integrated into the process and ensures a balanced signal reaching the left and right hearing aids by guiding the HCP if an imbalance is detected. Simultaneous binaural measurements will significantly reduce the length of the measurement and adjustment sequence. Another aim of this study is to investigate the time reduction when performing a binaural sequence simultaneously compared with sequentially, using REM AutoFit with Verifit*LINK*.

REM AutoFit speed and accuracy study

The present study described here investigates verification comparing automatic approaches to manual adjustments in terms of time and accuracy.

Previously, Folkeard and colleagues (2018) investigated time and accuracy by comparing the automatic verification using REM AutoFit with Verifit*LINK* to manual clinician fit (measurements and adjustments), and first fit (just measurement; no adjustments). Amongst other aspects, they investigated: time to verify and adjust to match targets, and accuracy using Root Mean Square Error (RMSE). RMSE was calculated as the difference between measured output and target at five frequencies, 0.5, 1, 2, 4, and 6 KHz at a given input level. Before any adjustments, the average RMSE was 6.7 dB. They found that it took significantly less time to match target using REM AutoFit with Verifit*LINK*, compared to manual clinician fit, and that the fit to target did not significantly differ between these two conditions. In addition, the average RMSE stayed below 5 dB. This is within the recommended +/- 5 dB deviation, defined by the British Society of Audiology (2018) as the tolerance

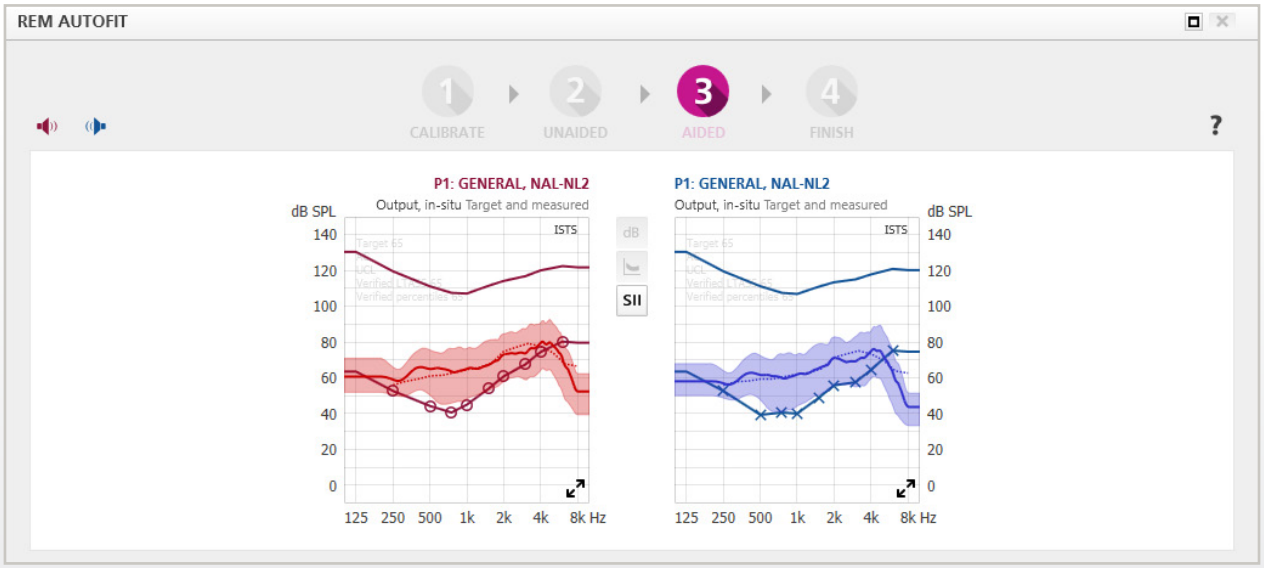

Figure 1. *Speech mapping measurements using REM AutoFit with IMC 2.*

** If supported by REM system*
*** Serial number 2070 and higher*

for a target match, with 4.3 and 3.8 dB RMSE for Verfit*LINK* and manual clinician fit, respectively.

As an extention to Folkeard and colleagues' (2018) investigation, the present study includes the two above mentioned updates to REM AutoFit. Two aspects investigated are: 1) time to perform adjustments and verification of target binaurally, and 2) accuracy. Since accuracy had been shown for Verifit*LINK* previously in Folkeard et al (2018), the present study only investigates accuracy of Manual Fit versus REM AutoFit with IMC 2. The conditions and aspects examined can be seen in table 1 below.

Method

Nine HCPs with previous experience performing verification were recruited to perform REAR measurements at low, medium and high input levels with International Speech Test Signal (ISTS) for all four fitting procotols.

The fitting protocols were:

- Manual Fit: an experienced audiologist manually adjusted the hearing aids in Genie 2 to match the DSL adult targets (REAR) on Interacoustics Affinity Suite version 2.13.0.
- REM AutoFit with IMC 2: Genie 2 | 2019.2 communicates directly with Interacoustics Affinity Suite version 2.13.0 or higher to present input signals and measure REAR (simultaneous binaural). The hearing aids are adjusted through the automatic procedure to match the DSL targets.
- REM AutoFit with Verifit*LINK* (sequential): Genie 2 | 2019.2 communicates directly with a Verifit2 (software version 4.16.3) using Verifit*LINK* to present input signals and measure REAR. The hearing aids are adjusted through the automatic procedure to match the DSL targets; first running initial measurements on each side one after the other and then the gain-adjusted measurements.
- REM AutoFit with Verifit*LINK* (simultaneous): Genie 2 | 2019.2 communicates directly with a Verifit2 software version 4.17.78 or higher using Verifit*LINK* to present input signals and measure REAR. The hearing aids are adjusted through the automatic procedure on both sides simultaneously to match the DSL targets.

The Canadian Audiology simulator for Research and Learning (CARL) from AHead Simulations was used as a client. This is an artificial head incorporating silicone ears with realistic anatomy. We simulated an N3 standard flat and moderately sloping hearing loss (see Bisgaard et al, 2010) fitted binaurally with Oticon Opn S, 85 receivers and Bass Domes, single vent.

Time is calculated as the time between the first click to start measurements until either the HCP states that they accept the target match or until the automatic sequence finishes depending on the fitting protocol.

Accuracy is measured by finding the RMSE of the deviation of measured output from target in dB across frequencies 1, 2, 4 and 6 kHz. 0.5 kHz was excluded from the RMSE measurement because we see drop-off at low frequencies and we used standard bass domes, where individual vent effect cannot be predicted, as it depends on varying insertion.

Results

Time

The results (see figure 2) showed that compared to manual fitting, REM AutoFit with IMC 2 was significantly faster and could be performed in less than 2 minutes. The upgrade that allowed for simultaneous binaural measurements with Verifit*LINK* also significantly reduced time; adjusting and verifying target was performed in less than 2 minutes and 30 seconds when running binaural simultaneous measurements with Verifit*LINK*.

Fitting protocol	Manual fit	REM AutoFit with IMC 2	REM AutoFit with Verifit*LINK* (sequential binaural)	REM AutoFit with Verifit*LINK* (simultaneous binaural)
Examined aspect(s)	Time and accuracy		Time	

Table 1. *Overview of fitting protocols and examined aspects*

The time to perform manual verification is longer in the present study (mean = 9 minutes 41 seconds) compared to the previous study by Folkeard et al (2018) (mean = 7 minutes 16 seconds). The longer average time may be partly explained by the use of a different audiogram, the involvement of different clinicians (who do not perform REM on a daily basis), as well as the test set-up where CARL was used as the client. Although clinicians were told to perform REM as they would usually do, having a test set-up focusing on REM that did not involve a live client, it is likely that clinicians spend more time to adjust than they would if sitting with a live client.

These are the results of only the measurement sequence across three input levels. This means that further time is required across all conditions, e.g. client instructions, probe and hearing aid placement and further manual adjustments based on client feedback.

Accuracy

When looking at accuracy of the Manual Fit condition and the REM AutoFit with IMC 2 condition, all average values of RMSE measured at 1-6 kHz were <5 dB, which means deviation from target stayed within the recommended +/- 5 dB (British Society of Audiology, 2018); the average across all three levels was 3.35 and 2.08 dB RMSE for Manual Fit and REM AutoFit with IMC 2, respectively. Figure 3 shows the average RMSE across all three input levels for manual fit and REM AutoFit with IMC 2. When assessing the individual input levels no difference is found between Manual Fit and REM AutoFit at 50 dB and 80 dB, while REM AutoFit with IMC 2 is significantly closer to target at 65 dB. The results may reflect the reality of HCPs when performing REM, which is the balance between spending as little time as possible and matching target. It may also be impacted by different ways of assessing the deviation of output from target. The deviation from target is assessed based on the options available from manufacturers, i.e. table view window of Affinity Suite when performing manual measurements and floating graph curve display in Genie 2 when performing REM AutoFit with IMC 2, thus reflecting what is available for the HCP. However, both REM AutoFit with IMC 2 and Manual Fit matched target across all three input levels since RMSE was <5 dB. Furthermore, the RMSE values for Manual Fit found in the present study fall within the standard deviation of the RMSE values of Folkeard et al. (2018), suggesting similar levels of accuracy across both studies. The average RMSE was lower than that reported for REM AutoFit with Verifit*LINK* by Folkeard and colleagues (2018) but this is likely to be due to the present study's use of a head simulator instead of live clients, a symmetrical hearing loss and the use of one less frequency for accuracy analysis.

As with conventional REM, clinicians need to use their clinical judgement to assess the target match to decide whether they need to proceed to the Manual section in REM AutoFit to perform additional manual adjustments and measurements.

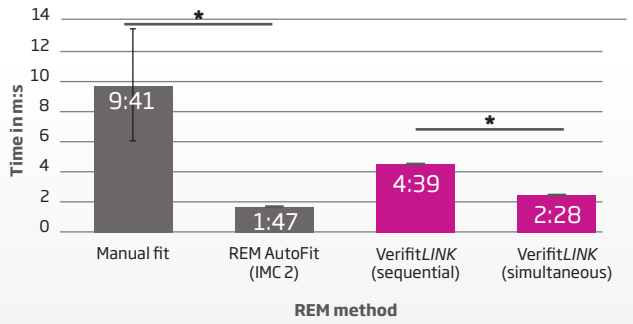

Figure 2. *Time to adjust and verify target across fitting protocols expressed in minutes and seconds.*

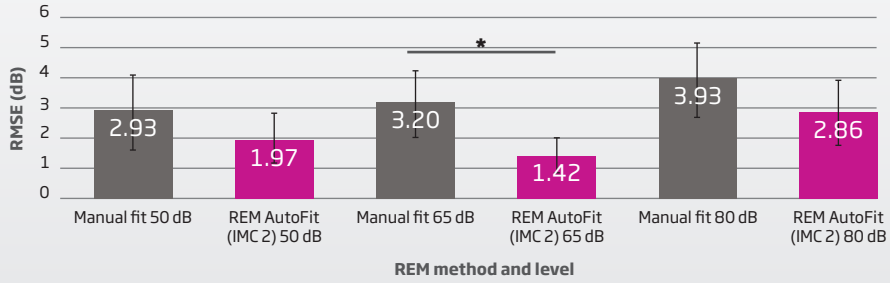

Figure 3. *Deviation from target in RMSE dB for Manual Fit and REM AutoFit (IMC 2) for input levels 50, 65 and 80 dB. Values below 5 dB qualify as a target match.*

Conclusion

With IMC 2, HCPs can now use speech mapping and with Verifit*LINK* they can now run binaural measures simultaneously. The updates to REM AutoFit provide benefits in terms of saving time. This was shown in the present study and the previous Folkeard et al (2018) study, where the automatic verification methods provide reduction in time spent on the measurement and adjustment sequence compared to the conventional manual verification method. As seen in Folkeard et al (2018) and in the present study, accuracy can be maintained when performing automatic verification. HCPs can still use clinical judgement to manually apply and measure further fine-tuning. The important consequences of spending less time on matching targets are that hearing aid users benefit from quick verification while clinicians follow best practice guidelines and free up time they can spend on other aspects of clinical practice.

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Notes:

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