Probe-mic Measurements for Today’s Hearing Instruments

Navid Taghvaei, AuD
Overview

- Research
- Measurement Definitions and Clinical applications
  - REUG; REOR; REOG; REAR; REAG; REIG
- Speech Mapping
  - Percentile Analysis
- Open Fittings
- Coupler measurements
  - Method 1
  - Method 2

- Auto-REM
- AutoFit
- VerifitLINK
- Auricle
- Measurement of Fitting and Features
  - REAR (Speech Mapping)
  - REIG (Insertion Gain)
  - Open Fittings
  - Directional Microphones
  - Digital Noise Reduction
Probe-microphone measurement

- Probe-microphone measures are an essential component of fitting hearing instruments, yet only 1/3 of HCPs routinely perform them.
- Consumer Reports concluded in July 2009 show that 2/3 of all hearing aid fittings are done incorrectly, and that probe-microphone testing is a “must-have” procedure for every consumer purchasing hearing aids.
- Experts in the field have suggested that the failure to use probe-microphone measures in the fitting of hearing aids is unethical.
Use of PMM for verification

Compliance with Best Practice Guidelines

- Mueller and Strouse (1995): PMM 54% for audiologists and 18% for HISs
- Mueller (1999): PMM use by those who had access to equipment, overall 44% use
- Mueller Survey (2003): 37% overall PMM routine use
- Mueller (2005) observed that the popularity of PMM among audiologists only:
  - 34% overall use (40% among recent graduates)
- Mueller & Picou (2010) concluded that the actual use rate is not even as high as their results showed
  - 25% of participants responded as doing PMMs that don’t even exist

Figure 2. Percent of respondents who routinely use probe-microphone measures on the day of the fitting. The “Have Equipment” data include only respondents who own or have access to probe-mic equipment.
Why Conduct Probe Microphone Measures?

Isn’t first fit enough?
Proprietary Fittings

- Keidser et al. (2003) showed that recommended algorithms of 5 different manufacturers were commonly different by 10 dB or more from NAL-NL1 in high frequencies for average-level inputs.

- Bentler (2004) showed that default algorithms of 6 different premier products/different manufacturers for a 65 dB input:
  - Generally all below NAL-NL1 targets
  - In important frequencies (e.g. 2K) difference was as much as 15 to 20 dB

Aazh and Moore (2007)

**Pass Criterion:** within 10dB of NAL NL1 insertion gain targets from 0.25-4kHz

**Findings:**
- 64% fittings “failed” one or more frequencies from 0.25-4kHz
- 83% of the fittings “passed” after adjustments
- 100% “passed” between 250-2kHz after adjustments
Aazh, Moore, and Prasher (2012)

**Pass Criterion:** within 10dB of NAL NL1 insertion gain targets from 0.25-4kHz

**Findings:**
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- 83% of the fittings “passed” after adjustments

Without PMM for open fittings, what % of your “NAL” fittings would be close to target?
Historical Review
Do we still need PMMs?

Hearing aids First Fit to NAL-NL 2; no adjustments

Difference between NAL-NL2 (0 dB line) and First-Fit REAR for 5 premium hearing aids @ 55, 65, and 75 dB SPL

Current Prescriptive Approaches

Western
National Centre for Audiology
DSL v5.0

- DSL has been used since 1984
  - Richard Seewald

- Several versions

- DSL v5.0a first available in 2005
  - Summary of changes in DSL v5.0 is provided in Scollie (2007):

<table>
<thead>
<tr>
<th>Change Description</th>
<th>Change amount and direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult/acquired versus pediatric/congenital target</td>
<td>7 dB reduction for moderate losses, 3 dB for severe losses.</td>
</tr>
<tr>
<td>Interpolation</td>
<td>Greater number of target values across frequencies when working with partial audiograms.</td>
</tr>
<tr>
<td>Compression threshold</td>
<td>Less gain and output for low-level inputs due to prescribed compression threshold. Inputs of 70 dB and above are not affected.</td>
</tr>
<tr>
<td>Output limiting</td>
<td>Narrowband output limiting targets largely unaffected. Output limiting for speech may cause target reductions of 5 to 10 dB if hearing loss is severe or test level is high.</td>
</tr>
<tr>
<td>Quiet versus noisy environments</td>
<td>Compression threshold raised by 10 dB and gain reduced at low-importance speech frequencies by about 5 dB.</td>
</tr>
<tr>
<td>Binaural fittings</td>
<td>Optional. Will reduce targets for speech by 3 dB. Output limiting targets are not affected.</td>
</tr>
<tr>
<td>Conductive or mixed hearing loss</td>
<td>Increases gain by up to 9 dB for mild losses, 5 dB for severe losses, depending on magnitude of air-bone gap.</td>
</tr>
</tbody>
</table>
NAL-NL2

- National Acoustic Laboratories (NAL) has been used since 1976
  - Harvey Dillon

- Multiple versions
  - NAL-R (1986)
  - NAL-NL1 (non-linear version)
  - NAL-NL2 is used today in 2 versions
    - Tonal
    - Non-tonal

Findings from previous versions resulting in changes to NAL-NL2

<table>
<thead>
<tr>
<th>Findings</th>
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<tbody>
<tr>
<td>Males prefer slightly more gain than females</td>
</tr>
<tr>
<td>Experience users w/ moderate/sever loss prefer more gain than new users</td>
</tr>
<tr>
<td>Users prefer slightly higher compression ratios than NAL-NL1</td>
</tr>
<tr>
<td>Less gain for bilateral fittings (loudness summation)</td>
</tr>
<tr>
<td>Children prefer more gain than adults (especially for low inputs)</td>
</tr>
</tbody>
</table>
Comparison of Current Prescriptive Algorithms

- Johnson & Dillon (2011), reported differences in insertion gain for seven different audiograms (5 SNHL)
Comparison of Current Prescriptive Algorithms

- Johnson & Dillon (2011)
Consumer Loyalty

- Kochkin, et al. (2014)
  - Relationship between customer satisfaction and customer loyalty (Heskett et al. 1994)
Consumer Loyalty

- Kochkin, et al. (2014)
- 7-point Likert scale on the following factors:
  - Professionalism
  - Knowledge level
  - Explained care of the hearing aid
  - Explained hearing aid expectations
  - Quality of service during the hearing aid fitting
  - Quality of service post-fitting
  - Level of empathy

![Bar chart showing % loyalty (Would recommend HHP)](chart.png)

**Was verification & validation used to fit hearing aid?**

- Neither verification nor validation: 57.4%
- Verification only: 66.9%
- Validation only: 75.9%
- Verification + Validation: 84.3%

- [Virtual Student University](https://www.vsu.com)
Measurement Definitions
Preparing Insitu Measurements

- Always check the ear canal to be free of obstacles and ear wax by using an otoscope
- The ear drum should be clear and transparent and not perforated
- Use fresh probe tubes for each patient and calibrate it before use
- Set the marker of the probe tube according to your patients’ ear canal length. The probe tube should end approx. 5 mm in front of the ear drum when the marker is at the tragus notch
- Insert the probe tube into the ear canal
- Check probe tube position with the otoscope
For starters –
What is the difference between terms that end in “R” vs. “G”? (e.g. REUR vs. REUG)

- “R” – refers to Response-- as an absolute measure of output in SPL. There is no consideration given to the input level used to generate the response

- “G” – refers to Gain and is a difference measure. Input has been subtracted from the output level across frequencies
Measurement Definitions

Real Ear Unaided Gain – Open Ear Gain

- Open ear resonance reflects the natural amplification of the signal by the outer ear.

- It is required to calculate the Insertion Gain during Insertion Response measurements.

- It is required for transferring AC, MCL or UCL values from dB HL to dB SPL (SPLogram view: Particularly for comparing Aided Responses).

- It is typically showing two peaks, one resonance peak at 2-3 kHz and one from shoulder reflection at bit higher.

- Shallow insertion of the probe tube will result in notches in the frequency response. Avoid a notch appearing under 6 kHz.
Real Ear Unaided Gain

REUG - Measurement

- Probe microphone system must be calibrated and/or equalized
- Patient must be positioned appropriately
- Correct insertion and depth for the probe tube
- Present signal (calibrated) to the ear(s) within range of 50-80 dB SPL
  - A level of 65 dB SPL is a good number 😊
  - For better visualization, use a s signal with equal level across frequency

REUG – Clinical applications

- Use as a baseline in the calculation of REIG (REAG-REUG)
- REUG also used in:
  - Baseline for REOG
  - For individualized 2cc coupler fitting target
  - Examining appropriate depth of insertion
  - Assist in detection of abnormal ME issues (perfs, etc...)
Real Ear Unaided Gain – Age dependency

- Open ear resonances are age dependent for kids age 3 and younger
- The resonance peak is dropping from 7 kHz with 4 month, to 2-3 kHz within two years
- Always try to measure the REUG from the ear that should be fitted. Or, at least copy it from the other side if available
- If no REUG can be obtained from either side, use the age dependent default values available from the application

Age dependent REUG curves for an age of 0 – 4 month, 9 – 14 month, 14 – 24 month and above. The resonance peak comes down from 7 kHz to normal (2-3 kHz).
Measurement Definitions

Real Ear Occluded Response

- Measured with the probe tube placed in the ear canal with the hearing instrument and its coupling in place and “turned off”
- Should be identical to REUR with a truly “open” fitting

Real Ear Occluded Gain

- Measure of how the coupling and the hearing instrument have changed the REUG and now serve as an ear plug
- Instruments and coupling will be in place and “turned off”
- Should be very similar to REUG with a truly “open” fitting
Different Degrees of Occlusion

**REUR**

**REOR open**

**REOR semi-open**

**REOR closed**
Real Ear Occluded Gain

REOG - Measurement
- Probe microphone system must be calibrated and/or equalized
- Patient must be positioned appropriately
- Correct insertion and depth for the probe tube
- Coupling/instrument in ear; and “turned off”
- Present a calibrated signal (same as REUR)
  - Display:
    - REOG
    - REOR (easiest to see effect)
    - REOR and REUR together
- Note REOG/REOR

REOG – Clinical applications
- Detection of any acoustic leaks from the coupling
- Selection of appropriate coupling
- Detection of venting effects
- Detection of amplified vs. Direct sound in REAR
**Measurement Definitions**

**Real Ear Aided Response**
- Measured with the probe tube and hearing aid placed in the ear canal and the hearing aid “turned ON”
- Reflects the dB SPL measured at the ear drum

**Real Ear Aided Gain**
- The difference between SPL provided by the hearing instrument at the probe tube and the input SPL (REAR – input = REAG)
Probe Tip Placement

An example of Insertion gain when comparing different depths of probe-mic insertion.
Real Ear Aided Response

REAR - Measurement
- Probe microphone system may require to calibrate and/or equalize
- Patient must be positioned appropriately
- Correct insertion and depth for the probe tube
- Instrument “first fitted” to a validated fitting algorithm and placed in the ear with coupling
  - All features on (depending on goals of the fitting)
- May be necessary to calibrate the reference microphone
- Present recorded/calibrated speech or speech-like signal
- Make programming changes to achieve desired output
- Move to next input level using 55, 65, and 75 dB SPL

REAR – Clinical applications
- Match output to desired prescriptive targets
- Calculation of aided audibility
- Calculation of REIG
- Examination of ALDs
Measurement Definitions

Real Ear Insertion Gain

- Measured with the probe tube placed in the ear canal with an earmold or HI inserted and “turned on”
- Reflects the amount of gain provided by the HI for each presented frequency (REAG – REUG = REIG)
- Used to determine whether a particular HI setting has achieved the desired insertion-gain prescriptive target
REIG Measurement

- Probe microphone system must be calibrated and/or equalized
- Patient must be positioned appropriately
- Correct insertion and depth for the probe tube
- Calibrate reference mic if necessary
- Measure REUR (or use average)
- “First fit” (to a validated target) and place instrument in/on ear
  - All adaptive features should be “on”
  - Freq. lowering may be an exception
- Use a calibrated speech signal (e.g. ISTS); at the same input level as your REUR
- Record REIG; make fine tuning adjustments to achieve satisfactory output (target)
- Repeat abovementioned by starting with REUR for the next input level until soft, medium, and loud have been matched to target
What am I looking at?

- Probe-microphone measures are the only way to verify how much sound you are really delivering to the patient’s ear drum.

- Manufacturer curve displays are based on averages and show what we think is being delivered, but can be affected by individual:
  - Ear-canal volume
  - Ear-canal resonance
  - Venting
Measurement Definitions

Speech Mapping - Use of a recorded speech signal to verify that soft- and average-level speech inputs are audible

- Usually measured at 55- or 50-dB SPL for “soft” and 65dB SPL for “average”

- Convenient because adaptive parameters of the hearing instrument do not need to be turned off
Percentile Analysis

- Speech mapping measurements with the International Speech Test Signal (ISTS)
- Graphic display of the dynamic range of a complex input signal.
- Presets default to percentile analysis for 3 input levels
- 1/3 octave band filtering: comparable to conventional probe microphone measures
- Allows fitting to output SPL targets, or gain targets
Percentile Analysis

- Select Percentile 65dB
- Run the measurement and adjust the LTASS to the chosen prescriptive target
- Watch that the 30% percentile at 1 kHz does not fall below the hearing threshold (circled)
Percentile Analysis

- Select Percentile 55dB
- Run the measurement
- Primary goal is to place the aided output above the HTL, preferably close to target
- 30% percentile values might fall below the hearing threshold levels
Unity 3: ISTS-MPO

- Check for high-level comfort
- Select the ISTS-MPO signal
- Engage UCL Limiter to ensure measurement pauses if UCL is exceeded at any frequency
- Run the measurement
- Peaks should stay below the UCL
- Adjust MPO if necessary
Video on percentile analysis
Open vs. Closed

Open vs. Closed fittings

Definition of open fit:

- An open fit is one in which the physical insertion of the hearing instrument minimally impacts the ear’s natural resonance.

- REOR (real-ear occluded response) is similar to the REUR (real-ear unaided response).

- In other words, when the hearing instrument is in the ear & turned off, the natural resonance of the ear is the same or very similar.
Open vs. Closed

Additional considerations for open fit:

- Turn off reference mic as the amplified signal can potentially reach the reference mic and cause the test stimulus to reduce in intensity
- Most REM equipment have open-configuration options
- An equalization measure is performed to adjust the test signal
Open Fitting Workflow

When fitting RIC or BTE instruments use the “Open fitting” option.

The system uses the semi-compensation method, where the compensation values are first obtained and stored and then used during the real measurement.

A workflow instructs the user when to turn hearing instruments off, then on again.

Use Connexx Mute button to switch HIs to off and on again.
Probe-tube Placement Methods

**Visually assisted positioning**, ANSI S3.46, B.2
- Otoscopic inspection
- Mark probe tube to guide placement

**Acoustically assisted positioning**, ANSI S3.46, B.3
- Otoscopic inspection
- Run REUG - note shape of 4-6 kHz region
- Move tube about 2 mm closer to TM
- Re-run REUG; repeat if shift occurs, until stable

**Average length method**
- Average length, 2.5 cm (1 inch)
- Goal of getting within 5-6 mm of TM
Measurement Definitions

Real Ear Coupler Difference

▪ The difference between hearing aid output in the ear vs. output in the coupler:
  ▪ Hearing instrument fitting can be performed in a 2cc-couple inside the test box
  ▪ The individual residual ear canal volume can be considered using statistical averages rather than a measurement for every patient…
  ▪ Are independent of a specific hearing instrument!
  ▪ Least effort for the patient and frequently recommended for pediatric fittings
RECD Measurement

- Use inserts or RECD transducer to PMM hardware
- Ensure software is configured to run RECD measurements
  - Calibrate transducer referenced to an HA-1 coupler (procedure will vary depending on PMM equipment)
    - One method requires attaching the transducer using foam inserts to the HA-1 coupler
    - Second method requires attaching the transducer to the patient’s earmold; blocking all venting, and putty the earmold to the HA-1 coupler
  - Speech weighted or pink noise is used for this calibration
  - PMM system may calibrate the transducer in a HA-2 coupler (w/out insert tip or earmold), and then apply a correction so that the measure is referenced to an HA-1 coupler.
- Use inserts or RECD transducer to PMM hardware
- Probe tube must be placed at the appropriate position in the patient’s ear canal with special consideration given to insertion depth
- Remove transducer from the HA-1 coupler (w/ earmold or foam ear tip) and place on/in patient’s ear
- Using the same signal used to calibrate HA-1 coupler, play signal through free-field speaker. Observe output in the ear canal. The difference between the couple and rea-ear values is the patient’s RECD (usually automatically calculated by the PMM system)
RECD Clinical Applications

- Predicting hearing instrument output in the ear canal (in situ) when 2-cc coupler values are known
- Capture coupler output and desired OSPL 90 settings
- For closed fittings, programming to equivalent real ear targets to hearing aids in the coupler
- REDD
RECD Measurement in Unity 3
Unity 3 supports two methods of RECD measurement:

**With Hearing Instrument:**
- Mostly used with adults
- Needs hearing Instrument
- Needs closed ear-mold
- Needs sound field speaker

**With Insert Earphones:**
- Preferred for pediatric care
- Does not need a HI but uses Inserts
- Foam tip coupling
- Remembers coupler values from previous measurements
Prerequisites to obtain RECDs

- To be able to perform RECD measurements with Unity 3, both the Fitting Unit and the HIT Unit must be available and connected to the PC via USB cable.

- Both, the REM and the HIT license must be active.

- Either a REM speaker and a Hearing Instrument (Method 1) or insert phones (Method 2) are required to perform RECD measurement with Unity 3. Both, ER-3A or Unity 3 Inserts are feasible for RECD measurements.
Select type of RECD measurement
Preparing the measurement

- Calibrate the probe tube

- Determine the appropriate tube length:
  - For reliable high-frequency sound during a measurement (e.g. aided response), the probe tube should exceed the ear-mold by at least 5 mm (decrease the influence of standing waves in the ear canal), but not touch the eardrum.
Method 1: RECD with Hearing Instrument

Method 1: RECD with Hearing Instrument

**Step 1:** Obtain insitu response with Hearing Instrument
Method 1: RECD with Hearing Instrument

Step 2: Obtain coupler response with Hearing Instrument.
Follow instructions on the screen, then press OK.

For BTE connect HI to BTE coupler. For Slim Tube or RIC instruments, use the RIC adaptor or some blue tack and the ITE adaptor to seal the tube/ERU to the coupler and make sure that the output flushes with the inner plain of the adaptor opening.
Method 1: RECD with Hearing Instrument

Step 2: Obtain coupler response with Hearing Instrument.

Note: Coupler and Insitu Curve can optionally be made visible from the legend.
Possible pitfalls / Doubtful results

- Insertion of probe tube not deep enough
- Acoustical leak / venting
- Grommets or perforation
- Eardrum problems and / or otitis media (with effusion)

Possible root causes:

- Capping at 2 - 3 kHz
- Negative values at lower frequencies (-1 to -9 dB)
- Negative values at lower frequencies (-10 to -15 dB)
- High positive values at lower and mid frequencies
Method 2: RECD with Insert Phones
Method 2: RECD with Insert Phones

Step 1: Obtain the coupler response of the insert phone

In case a RECD has been measured for this client before, coupler response will be available to be reloaded instead of making a new coupler measurement.
Step 2: Obtain the insitu response
RECD Tips with Unity 3

- RECD measurement requires expert knowledge and experience whether the results obtained are valid.

- Method 1, using a hearing instrument, required the hearing instrument to be programmed to Test-settings in omni-directional mode. If the RECD curve is not satisfying, both the real ear and the coupler part needs to be measured again.

- Method 2 start with the Coupler part first and enables to redo the Real ear part as often as necessary without to redoing the coupler part again. (Beneficial and time saving especially for pediatric fittings)
Auto-REM

- AutoFit (Signia’s Auto-REM) automatically provides an optimized real-ear verification without the need to manually match targets.

- AutoFit allows for fast real-ear verification for prescriptive targets (e.g. NAL-NL2 or DSLv5), as well as offering the ability to verify proprietary targets*

- Target match is performed through the manufacturer’s fitting software.

- AutoFit is compatible with all levels of Signia hearing aids supported by the Connexx fitting software.

* Proprietary target matching not supported by all Auto-REM systems
Siemens Hearing Instruments introduced AutoFit nearly 20 years ago. As early as 2001, Mueller reported the following:

Top panel:
Initial real-ear fit-to-target following programming using 65 dB input signal (connected circles are desired target)

Bottom panel:
Fit-to-target following automated real-ear “first fit” procedure (Courtesy of Siemens Hearing Instruments)

Is AutoFit Reliable?

AutoFit is both valid and reliable and can be an efficient and useful tool in the verification of the hearing aid fitting via the new IMC2 standard.

Validity, Reliability, and Efficiency of the Signia AutoFit Procedure
Joachim Baumann, MSc, Thomas Powers, PhD, and Eric Branda, AuD


Tech Topic | September 2018 Hearing Review
AutoFit REM Equipment

AutoFit is supported on the following REM devices:

- Unity 2 from Cxx 7.1 onwards
- MedRX Avant REM from Cxx 7.1 onwards
- MedRX Avant REM+ from Cxx 7.1 onwards
- Aurical from Cxx 7.3 onwards (Aurical FreeFit)
- Unity 3 from Cxx 7.3 onwards
- Primus from Cxx 7.4 onwards
- Verifit from Connexx 9.1 onwards (All Verifit 2 and Verifit 1 with SN higher than 2070 or Higher and 3.26.2 firmware)
Audioscan Verifit® LINK Auto REM with Signia Connexx
Exploring VerifitLINK

VerifitLINK

- Communication link that allows Verifit to exchange data with fitting software

- Run SpeechMap tests, obtain targets & measurements, and adjust hearing aids without clinician intervention

- Operation is done through the hearing instrument manufacturer's fitting software
VerifitLINK Set Up

Verifit
- Make sure the Verifit Software is up to date
- Connect Verifit to Network
  - Verifit 2 can wirelessly connect
  - Verifit 1 needs hardwire connection and requires a router be in place
- Note the IP address

Connexx
- Make sure Connexx software is up to date
- Open Connexx through Noah or in standalone mode
- Confirm that Verifit is recognized
VerifitLINK and Connexx

Connexx set-up continued:
VerifitLINK and Connexx

Connexx set-up continued:
VerifitLINK and Connexx

Appearance in Connexx:
VerifitLINK and Connexx

Pure 312 X
Click sleeve closed
VerifitLINK and Connexx

Detect the hearing instrument(s):
VerifitLINK and Connexx

Prior to First Fit:

- Select appropriate Acoustical Parameters
- Select desired fitting formula – VerifitLINK will not work with proprietary fitting formulas
VerifitLINK and Connexx

Notes:

InSituGram – Optional
- Hearing test through the hearing aids that can be used instead of entered Audiogram

Critical Gain/Acoustical Behavior – Optional
- VerifitLINK will not apply statistical critical gain during the fitting process even though the pink and blue-shaded areas are shown
- If feedback occurs, do one of the following:
  1. Apply statistical critical gain limits; return to this screen after VerifitLINK fitting is complete and place a check mark to activate it
  OR
  2. Run individual critical gain measurements

RECD/REUG – Does not apply with VerifitLINK on-ear fittings

Note: *DO NOT* Recalculate, *this would change your verified fitting.*
Verifit\textit{LINK} and Connexx

After selecting Verifit\textit{LINK}, a pop-up window appears:
VerifitLINK and Connexx

Set-up screen:

- Allows you to change parameters
- Gives instructions
- Allows you to check the calibration
- Insert probe tube in ear(s)
- Place hearing instrument in ear(s)
VerifitLINK and Connexx

When ready, select Verifit Measurements:
VerifitLINK and Connexx

Start measurement:

- To initiate the VerifitLINK procedure, click the Start button. Measurements will be performed on all the selected input levels automatically.
Verifit\textit{LINK} and Connexx

Video of Verifit 1 & Connexx during Verifit\textit{LINK} measurement and adjustment:
Manual adjustment option – increased gain 2-4K Hz for better target match then re-run measurement:
VerifitLINK and Connexx

Manual adjustment verified:
VerifitLINK and Connexx

Apply VerifitLINK results and Close

<table>
<thead>
<tr>
<th>Setup</th>
<th>Verifit Measurements</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>sDemo (Pure 312 7X S (108/...</td>
<td>sDemo (Pure 312 7X S (108/45))</td>
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<td></td>
<td><img src="image1.png" alt="Graph" /></td>
<td><img src="image2.png" alt="Graph" /></td>
</tr>
</tbody>
</table>

What would you like to do with the results?
- Apply VerifitLINK results
- Discard all changes

Close
VerifitLINK and Connexx

VerifitLINK First Fit and Verification is completed – Individualized fitting may be under or over the curve display targets.
AutoFit with IMC 2 compatible REM modules
Connexx AutoFit

IMC2 and proprietary protocols

- AutoFit performs automated target match for both sides for open or closed fittings
- Identical User Interface used for different REM modules
- Provides Connexx proprietary targets as well as NAL-NL2 or DSL v5
- Supports binaural tube calibration, REUG and REIG measurement
- Verification with 80 dB input signal can be performed after fitting
Connexx AutoFit

Select REM Module

▪ Open preferences and select Devices
▪ Unfold the REM Devices/Modules section
▪ Select option “Available REM modules”
▪ Choose:
  ▪ select entry “Otosuite” for Aurical Free Fit
  ▪ select entry “Unity Module” for Unity 3
  ▪ Select entry “VerifitLINK” for Verifit Etc…
Connexx AutoFit

Probe Tube Calibration

- Prepare probe tubes for calibration
- Place probes within 50 cm in front of the speaker
- Click on “Start Binaural” to run tube calibration for both sides simultaneously
- Gain curves are displayed in the screen.
Connexx AutoFit

Run REUG Measurement

- Insert tubes into ear canals
- Click on “Start Binaural” to run REUG measurement for both sides simultaneously
- REUG curves are displayed in the screen
Connexx AutoFit

Run AutoFit

- Insert hearing instruments into client’s ear
- Select AutoFit tab. Targets for 50, 65 and 80 dB are displayed.
- Click on “Start Binaural” to run AutoFit measurement for both sides simultaneously
Connexx AutoFit

Run AutoFit

- Insert hearing instruments into client’s ear
- Select AutoFit tab. Targets for 50, 65 and 80 dB are displayed
- Click on “Start Binaural” to run AutoFit measurement for both sides simultaneously
- Automated target matching for 65 dB is performed and resulting REIG curves displayed
Connexx AutoFit

Run Verification

- Proceed to validation tab
- Click on “Start binaural” to run validation measurement
- Measurement is performed with an 80 dB input signal
- REIG curves are displayed with a dashed curve, matching 80 dB targets (lower thin red line)
- Check “Keep AutoFit Result” and click on “Close” button to store the settings
AutoFit with Aurical
AutoFit with Aurical

- Modular system including Video Otoscopy, Audiometry, Counseling and Simulations, Probe Microphone Measurements, and Hearing Instrument Test Chamber

- Offers wide range of options for prescriptive fitting and special feature verification with built-in tools to guide the process

- OTOsuite platform streamlines diagnostic, fitting, and verification
Pre-requisites and practicalities - Aurical

- PMM must be functional in Otosuite outside of any integration (i.e. connected to PC, powered on, Otoair pairing complete)

- PMM Probes must be calibrated, and HIT must be calibrated for coupler integrated fittings

- Otosuite must remain closed during integrated verification operation
AutoFit with Aurical
Aurical AutoREM Troubleshooting

- Make sure all required software versions are installed
- Make sure Aurical is connected and functional for independent operation
- Make sure room calibration has been completed
- Make sure PMM probes calibration is up to date
- If issues cannot be resolved, set the error level on Otosuite to verbose, reproduce the unexpected behavior, return the Otosuite error log file in verbose format to Otometrics Hotline along with version information about operating system, NOAH/Office management system, Otosuite, Fitting software, HI used for the procedure and detailed steps to reproduce
## Implementation comparison - Aurical

<table>
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<tr>
<th>Guided probe tube insertion</th>
<th>ReSound</th>
<th>Phonak</th>
<th>Oticon</th>
<th>Signia</th>
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</thead>
<tbody>
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<th>Real Ear / Coupler</th>
<th>Real Ear</th>
<th>Real Ear &amp; Coupler</th>
<th>Real Ear</th>
<th>Real Ear</th>
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<th>Stimulus type</th>
<th>Speech Noise</th>
<th>ISTS</th>
<th>ISTS or speech noise</th>
<th>Modulated noise</th>
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<tr>
<td>Speech Noise</td>
<td>Speech Noise</td>
<td>ISTS</td>
<td>ISTS or speech noise</td>
<td>Modulated noise</td>
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</table>

<table>
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<tr>
<th>Stimulus levels (dB)</th>
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<th>50</th>
<th>65</th>
<th>65 (50 and 80 optional)</th>
<th>65</th>
<th>80</th>
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</table>
Dual Processing and OVP

Dual processing provides two separate processing paths:

- One is optimized for the own voice
- One is optimized for external sounds, i.e. soundscape

We achieve a natural sound quality while also ensuring clear speech understanding in noise.
Getting Started With OVP Video
Fitting Pure 312 Nx

Live Speech no OVP

Live Speech OVP activated
Fitting Pure 312 Nx Closed Sleeve

Notch therapy off Green
Notch therapy on at 4K Hz
Measurement of Fitting and Features
Matching Targets via REAR (Speech Mapping)

- Starting with programmed instruments to a validated target selecting appropriate patient and fitting factors

- Use appropriate speech or speech-like signal (e.g., ISTS, shaped real speech)

- Considering appropriate insertion and depth, place the probe tube in the patient’s ear
  - Mute the hearing aid and fit it to the patient’s ear

- After the physical fitting of the hearing instrument, unmute the hearing instrument and start the verification of the first input level in your protocol
  - Adjust frequency specific gain to achieve desired target match
  - Once a match to the 1st target is achieved, continue testing the remaining input levels
  - Do a final check of all three levels to make sure programming for one level did not significantly affect other already matched targets
Matching Targets via REAR (Speech Mapping)

Speech Mapping Tips

- Speech Map with all adaptive features “ON”
  - Except frequency lowering

- If your goal is fit to NAL-NL2 (for example), start with the same algorithm in the manufacturer’s software
  - This may impact WDRC release times
Matching Targets via REIG (Insertion Gain)

- Starting with programmed instruments to a validated target selecting appropriate patient and fitting factors
- Use appropriate speech or speech-like signal (e.g., ISTS, shaped real speech)
- Considering appropriate insertion and depth, place the probe tube in the patient’s ear
  - Conduct the REUR (using average may be a good idea)
  - Input level is not important; it will be adjusted to correspond to REAR levels
- Mute the hearing aid and fit it to the patient’s ear
- After the physical fitting of the hearing instrument, unmute the hearing instrument and start the verification of the first input level in your protocol
- Adjust frequency specific gain to achieve desired target match
- Do a final check of all three levels to make sure programming for one level did not significantly affect other already matched targets
Matching Targets via REIG (Insertion Gain)

Insertion Gain Tips

▪ Experts (Mueller et. al.) recommend using average REUG from your favorite PMM system. Using the patient specific REUG may lead to confusion with “unusual” canals.

▪ So you met the REIG target for soft speech.
  ▪ Did you make soft sounds audible?
  ▪ How do we know?

▪ This is why using REIG for verification is not Mueller et al.’s favorite 😊
Matching Targets for Open Fittings

- Change equalization method from “concurrent” to “stored”
  - Most systems allow for selecting “open” or a similar descriptor for the HI form factor
- Starting with programmed instruments to a validated target selecting appropriate patient and fitting factors
- Use appropriate speech or speech-like signal (e.g., ISTS, shaped real speech)
- Considering appropriate insertion and depth. place the probe tube in the patient’s ear
- Mute the hearing instrument and fit it to the patient’s ear
- Perform stored equalization and free-field calibration, unmute the hearing instrument
  - This process is also referred to as leveling and open calibration
  - **Patient must keep head in calibration position and cannot move it during signal presentation…**
  - Start the verification of the first input level in your protocol. Adjust frequency specific gain to achieve desired target match for soft, medium, and loud inputs.
Matching Targets for Open Fittings

Open Fitting Tips

- Using stored equalization, patient must not move from the position in which calibration was performed

- Most PMM manufacturers have an “open” fitting algorithm to make this process easy
Verification of Directional Microphone Technology

- Verify targets prescriptive targets via REAR or REIG

- Program hearing instruments to a “fixed directional” pattern

- If using a static signal, disable DNR

- Perform a REAR with the free-field speaker (at 0° Horizontal/vertical relative to the patient’s face) with the ISTS or real speech signal at 75 dB SPL

- Turn the patient 180° and perform a second REAR using the same input level
  - Comparing the two curves will indicate a good estimate of the function of directional mics
Verification of Directional Microphone Technology

Directional-Mic Testing Tips

- Testing on the day of the fitting or initial HIT eval will give you a baseline
- Directionality will vary significantly relative to how mics are positioned on the ear
- You can determine the knee/trigger points for automatic directional algorithms
- Disable DNR; unless seeking to test the combined effects
- Important to evaluate directional processing on repeat visits
  - Primary cause of poor directional performance is debris and dirt…

Polar Patterns

- Empty
- Omnidirectional
- Subcardioid
- Cardioid
- Supercardioid
- Hypercardioid
- Figure 8
- Shotgun
Verification of Digital Noise Reduction

- Verify targets prescriptive targets via REAR or REIG
- Use a “noise” signal (white, pink, speech, etc…)
- Turn off DNR and perform a REAR at 75 dB; this will be a baseline measurement
- Turn on DNR (meant for everyday use), and perform a REAR—test for at least 10 seconds for maximum effect
- Evaluate DNR for different programs; also observe the effect of different settings of digital noise reduction for future reference
Verification of Digital Noise Reduction

DNR Testing Tips

- It may be useful to use lower levels (from 75 dB, although 75 is recommended) for the assessment of DNR function to learn about different algorithms’ function

- The release time of DNR can be assessed by talking as the noise is presented
  - Ensure speech is well over noise in level
  - Generally fast (1 to 2 sec), but varies among manufacturers
  - Conducting a REAR using real speech with DNR turned ON/OFF, will show any effects of DNR on speech
    - There should be no effect 😊
WE DID IT!
AutoFit
Live Demo!
Questions?